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VOL. 11 JULY, 1924 No. 4

CAST IRON PIPE PRICES[1]

BY F. G. GORDON[2]

Cast iron pipe constitutes the largest single element of value of the average water works. The price of cast iron pipe therefore is of decided interest to the superintendent, the engineer and the appraiser.

The appraiser may be, and usually is, interested in past prices of cast iron pipe. The superintendent and engineer are much more interested in present and future prices. Will cast iron pipe remain at or near its present price for some time to come, or may we expect a return to pre-war prices within a reasonably short period of time, or will the price trend be somewhere between these two extremes? It would be an imposition on your intelligence and a reflection on his own for the writer to attempt to predict with accuracy the future price of cast iron pipe. It is possible, however, to analyze the elements which go to make up its cost and thus gain an idea of the way in which changes in these elements will affect prices.

For this purpose a consideration of past prices becomes necessary.

Figure 1 shows the price of 6-inch cast iron pipe at Chicago for the twenty-year period from 1904 to 1923, inclusive. It also shows the price of Southern No. 2 pig iron at Birmingham for the same period.

[1] Presented before the Illinois Section meeting, March 20, 1924.

[2] Hydraulic Engineer, Maury and Gordon, Chicago, Ill.

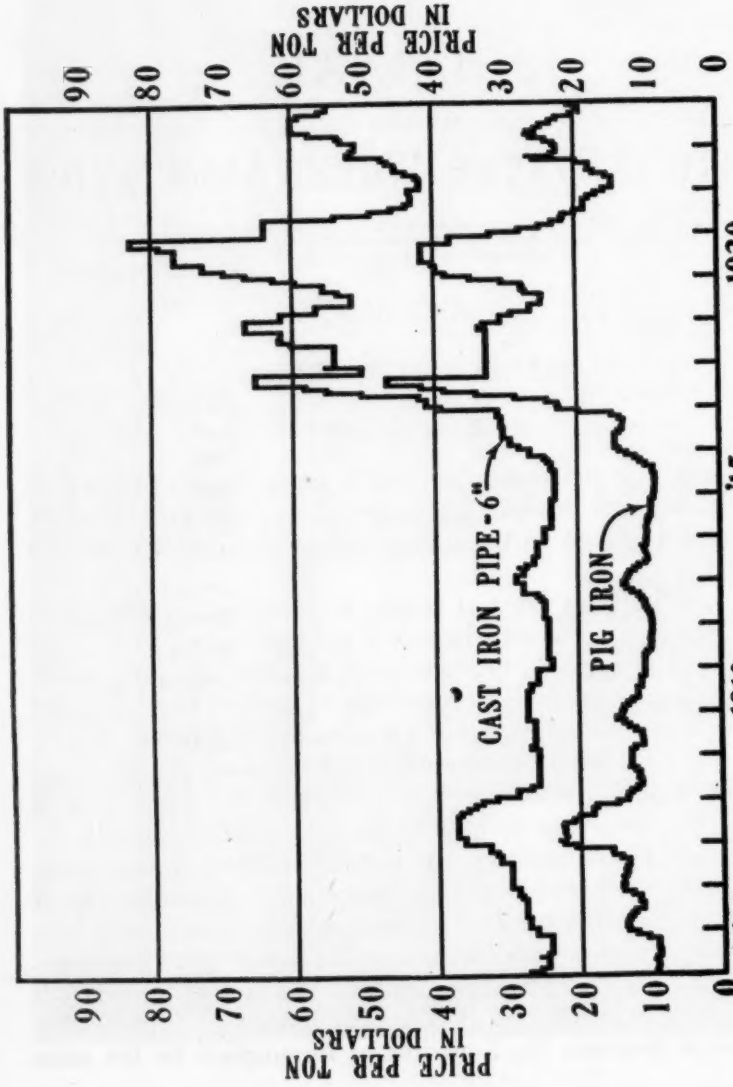
PRICE PER TON IN DOLLARS
90
80
70
60
50
40
30
20
10
0
'05
1910
'15
1920
YEARS
CAST IRON PIPE-6"
PIG IRON

FIG. 1

Six-inch pipe in 1903 reached a price of $35.00 f.o.b. Chicago, and in the spring and summer of 1907 exceeded this somewhat with a top price of $37.50. The ensuing financial depression caused a rapid decline so that by May, 1908, 6-inch pipe was selling for $26.00 per ton. From this date until 1916, or for a period of nearly eight years, the price of pipe fluctuated but little. However, starting with 1916 the fireworks began. Peak price followed peak price until in October, November and December of 1920 6-inch cast

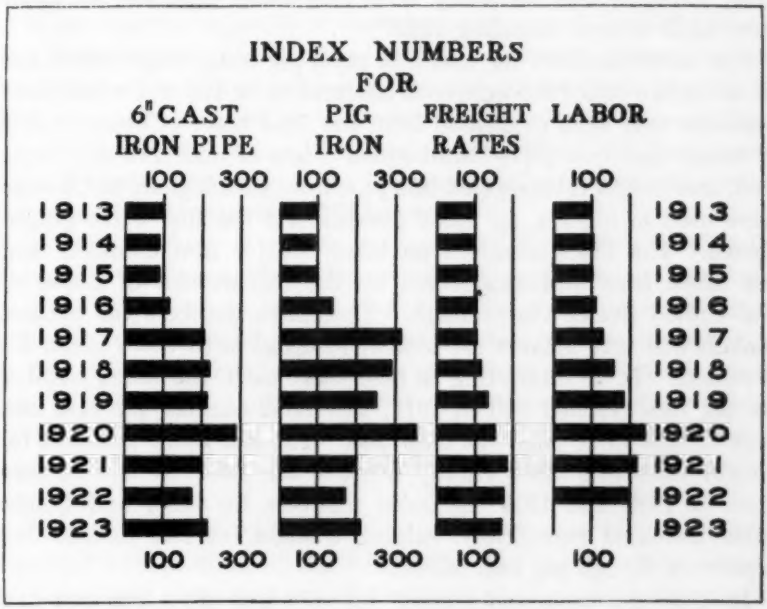

FIG. 2

iron pipe was quoted at the unbelievable price of $83.10 per ton f.o.b. Chicago. This peak price was followed by a rapid decline which carried the price to a figure of $43.35 just one year later. From this point the price has advanced gradually with minor fluctuation until today 6-inch pipe is quoted at $56.70 per ton f.o.b. Chicago.

This diagram well illustrates the close relation existing between the price of cast iron pipe and the price of pig iron. An increase in the price of pig iron is followed by a corresponding increase in the price of cast iron pipe, while a decline in the price of pig iron usually results in a falling off of cast iron pipe prices.

In addition to pig iron there are two other major elements which go to make up the price of cast iron pipe. These are manufacturing costs and freight rates. The variation in these factors in recent years has been almost as marked as the variation in the price of pig iron.

Figure 2 has been prepared in order to show how the change in these various factors has taken place. This diagram shows index numbers for 6-inch cast iron pipe, pig iron and freight rates from the base year, 1913, to and including 1923, and index numbers for labor from 1913 to and including 1922.

The index numbers for cast iron pipe, pig iron, freight rates and labor for the year 1913 were each assumed to be 100 and subsequent numbers were then calculated from the 1913 base. Chicago prices of 6-inch cast iron pipe, Birmingham prices of Southern No. 2 pig iron, and freight rates on cast iron pipe from Birmingham to Chicago were used in making up index numbers for the first three graphs shown. The index numbers on labor are for iron moulders and are taken from statistics issued by the Department of Labor of the United States Government. The index numbers for pattern makers and core makers are almost identical with those given for moulders. It is interesting to note that, while the index number for pig iron reached 310 in 1917, the index number for cast iron pipe in that same year was only 203. The low index numbers for freight rates and labor readily account for this. It will be seen that in 1918 and 1919 the index numbers for labor and freight rates increased perceptibly, causing a slight increase in cast iron pipe even though pig iron fell off.

In 1920 the peak was reached for cast iron pipe, pig iron and labor, while the peak in freight rates did not occur until 1921. This chart discloses the fact that, in comparison with the other three commodities shown, freight rates have had a rather moderate increase since 1913. The Department of Labor index number for 1923 for moulders was not available at the time this diagram was made, but it is probable that it was in excess of the figure for 1922.

Let us now consider what change may be expected in the near future in the factors which make up the cost of the finished pipe.

The cost of pig iron is a large element in the cost of cast iron pipe and an extremely uncertain one. Like most raw materials its price is affected to a greater extent by the law of supply and demand than is the finished product. If we are to expect a decided reduc-

tion in pig iron prices, we must expect a marked diminution in the production of iron and steel products. If one will compare the curve showing unfilled orders of the United States Steel Corporation with the curve showing pig iron prices, the correctness of this statement will be realized. The similarity between these curves is striking. Although the law of supply and demand will greatly affect pig iron prices, it must not be forgotten that freight rates and labor are two of the important elements of cost involved in the production of pig iron.

What may be expected of manufacturing costs? Skilled labor is one of the large factors here and probably enters to a greater extent than any other. A reduction in the cost of this item per unit of pipe may take place either as a result of reduction in wages or from improvements in the art of manufacturing pipe. At the present time it would appear as if the latter possibility offered the greater promise of a lowering in unit labor costs.

A process which is said to increase the production of pipe for the same number of men 100 to 150 per cent over the sand cast method has been adopted by two of the large pipe manufacturers. This is the de Lavaud process of casting iron pipe centrifugally.

The equipment required consists of a water cooled mould which can be rotated, a cantilever spout of sufficient length to extend to the end of the mould, a pouring ladle of special design, and a hydraulic ram for moving the mould in a direction parallel to its own axis.

The operation of making a pipe is this: A core is inserted and clamped into position at the bell end of the mould. This core is of the proper shape to form the bell end of the pipe. The mould is then moved forward on the spout until the end of the spout is near the bell end of the mould. The mould is then rotated and metal poured into the spout. The mould now moves away from the spout, thus combining a circular movement with a longitudinal one. During this operation the metal flows from the end of the spout into the mould, and due to the centrifugal action of the mould, is thrown to the outside, where it solidifies. It is readily apparent that with a uniform travel of the mould and with a uniform pouring of metal from the end of the spout a pipe of uniform thickness is assured.

The metal is poured into the spout from a tilting ladle, whose movement is hydraulically controlled. This insures a steady flow

of iron. After a pipe has been cast, clamps are inserted at the bell end which hold the pipe while the mould moves away from it. This results in the withdrawal of the pipe from the mould. After the pipes are cast they are moved immediately to an annealing oven in order to conserve as much of the heat as possible.

Pipe made by this process has a higher tensile strength than that produced by the sand cast method. Because of this and the further fact that a uniform thickness of wall is assured by this method, the weight of this pipe is 25 per cent less than that of standard sand cast pipe designed for the same head. This results in a saving in material and a saving in freight.

At the present time the cost of this pipe per linear foot at the foundry is approximately 95 per cent of the linear foot cost of standard pipe. The saving to the consumer comes from the fact that the weight of the pipe per foot is only about three-quarters of that of the standard pipe, which reduces his freight charges accordingly. It is probable that it will be a few years at least before the influence of this new method of manufacture makes itself felt in the price of of cast iron pipe.

It seems unreasonable to expect that there will be much of a reduction in freight rates for several years. Railroads are confronted with ever increasing taxes, with labor problems resulting from their dealing with some of the strongest labor unions in the country, and with more or less deferred maintenance, all of which factors tend to prevent a reduction in rates.

We are now in a position to sum up the various factors considered and to arrive at some conclusions concerning the future price of cast iron pipe. That fluctuations up and down will result from similar fluctuations in the price of pig iron is unquestionable. The general price trend should be slightly downward as the result of decreased manufacturing costs, but any decided decrease must await reductions in labor, freight rates and taxes.

In connection with this discussion of cast iron pipe prices, a study was made of the change in prices during the various months of the year in order to determine if there was any particular advantage to be gained financially by purchasing pipe during certain months or seasons. Over the twenty-year period from 1904 to 1923, inclusive, the lowest average price for any one month occurred in February, when this figure was $37.38. The highest average figure of $39.68 for 6-inch cast iron pipe came in December.

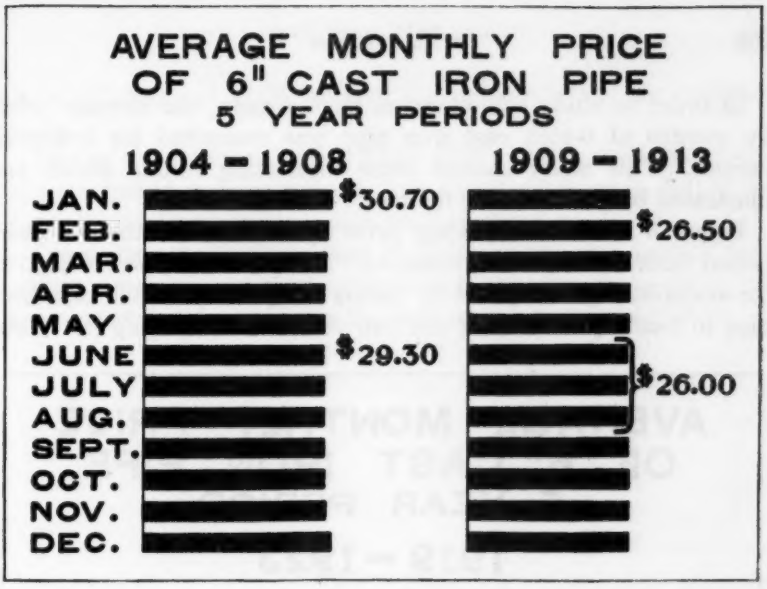
AVERAGE MONTHLY PRICE
OF 6" CAST IRON PIPE
5 YEAR PERIODS
1904 – 1908
1909 – 1913
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
$30.70
$29.30
$26.50
$26.00

FIG. 3

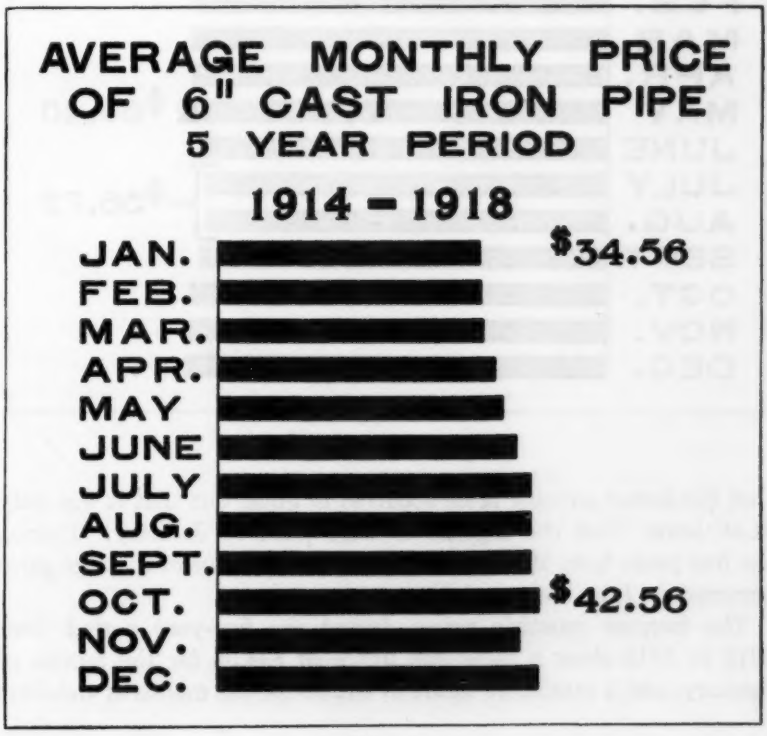
AVERAGE MONTHLY PRICE
OF 6" CAST IRON PIPE
5 YEAR PERIOD
1914 – 1918
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
$34.56
$42.56

FIG. 4

In order to study this question more closely, the average price by months of 6-inch cast iron pipe was computed for five-year periods. This study showed some interesting results which are illustrated by the following figures.

Figure 3 shows the average price by months for the five-year period from 1904 to 1908, inclusive. The January price of $30.70, for example, was computed by taking the price of 6-inch cast iron pipe in January of each of the five years and averaging it. Note

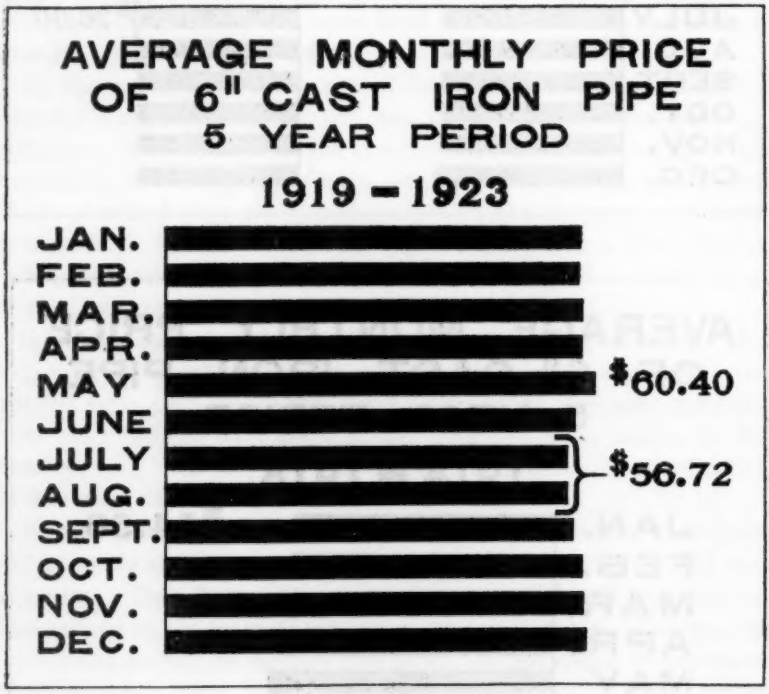

FIG. 5

that the lowest average price occurred in June, but that it was only $1.40 lower than the highest average price in January. During the five years from 1909 to 1913, inclusive, the lowest average price occurred in June, July and August.

The average monthly prices during the five-year period from 1914 to 1918 show a minimum figure of $34.56 for the month of January, and a maximum figure of $42.56 for the month of October;

or, a difference of $8.00 between the maximum and the minimum prices.

During the five-year period from 1919 to 1923, inclusive, $56.72 was the lowest average price in July and August; while $60.40 was the highest average price. This price occurred in May.

These diagrams indicate that in fifteen of the past twenty years better prices were obtained by summer purchasers, while during one five-year period January was the best month to purchase pipe.

THE FUTURE OF WATER RESERVOIR PROJECTS IN ILLINOIS AND THEIR RELATIONSHIP TO GEOLOGIC DATA[1]

By M. M. Leighton[2]

The underground water resources of northeastern Illinois are perhaps better known than in any other part of the State, due to the intensive industrial development which has gone on there. The water horizons in this part of the State belong to the lower part of our State's geologic column. They include the Niagaran dolomite, Galena-Trenton series, St. Peter sandstone, Prairie du Chien series, and "Potsdam" sandstone. The depth to the "Potsdam" sandstone ranges from about 550 feet in Winnebago County to about 1400 feet at Chicago, and the depths to the other successively higher horizons are correspondingly less.[3] Ordinarily, most of these aquifers furnish abundant supplies, but the excessive requirements in the vicinity of Chicago are a tax on nature to supply the water as rapidly as it is used, and as a result the static head is rapidly lowering. This fact has been brought out clearly by Mr. C. B. Anderson in the publication just referred to in the footnote, and with added force by Mr. Isham Randolph in his series of two articles which appeared in the *Chicago Daily News*, September 12 and 13, 1923. The proximity, however, of this territory to one of nature's largest fresh water reservoirs, Lake Michigan, reduces the apprehension which might otherwise attend this problem, but it is not true in the case of central and southern Illinois, where several municipalities have now reached a critical situation with regard to their water supply.

In central and southern Illinois many of the county seats and larger towns have heretofore drawn their water supplies from the

[1] Presented before the Illinois Section meeting, March 19, 1924.

[2] Chief, State Geological Survey, Urbana, Ill.

[3] For detailed information the reader is referred to Carl B. Anderson, The Artesian Waters of Northeastern Illinois; Ill. State Geol. Survey Bull. 34, 1919.

glacial drift. This is true of Urbana and Champaign. In the case of glacial drift, sand and gravel strata are likely to occur in old river valleys which were buried by the deposits of glacial drift. The existence of these old river valleys may not be revealed by the present topography, but may be ascertained by the assembling of well data. This is one reason why the Illinois Geological Survey stresses and appreciates the faithfulness of all drillers in sending in accurate logs of their wells. The old buried Rock River Valley of northern Illinois has been fairly well delineated and its buried gravel deposits furnish a part of the water supply of the City of Princeton. Less is known about the buried valleys of central and southern Illinois, and we are anxious to secure data on the same. Modern valley alluvium is a well-known source of supply and locally is important, as at Peoria. At Springfield, however, it is proving inadequate, and a reservoir project is being planned. Normally, drift wells are shallow, and although adequate for a while, it is only a question of time when many towns will have to look elsewhere for this great necessity. A critical situation having already developed for some of them, they are facing the question as to what other source they can draw upon. There are two possibilities: (1) deeper aquifers; and (2) surface water reservoirs. Let us examine these two sources.

CHARACTER AND STRUCTURE OF THE GEOLOGIC STRATA IN CENTRAL AND SOUTHERN ILLINOIS

The geologic column for Illinois is as follows:

Groups	*Systems*
Cenozoic	Recent
	Pleistocene
	Tertiary
Mesozoic	Cretaceous
Paleozoic	Pennsylvanian
	Mississippian
	Devonian
	Silurian
	Ordovician
	Cambrian

In the more northern part of Illinois, the Tertiary, Cretaceous, Pennsylvanian, Mississippian, and Devonian systems are largely absent,

and the Silurian and Ordovician formations outcrop at the surface, except where covered with glacial drift and recent deposits. Farther south, the Silurian, Ordovician, and Cambrian formations dip deeper and deeper as distance increases, and are buried by Devonian, Mississippian, and Pennsylvanian formations. The well driller can not help but be impressed with the notable changes which take place, especially south from the Upper Illinois River. When it is remembered that each of these systems comprises at least two formations, and in some cases, as in the Ordovician system, many different formations, and that most of these formations have thicknesses ranging from 100 to 300 or 400 feet and that their aggregate thickness is to be measured in terms of thousands of feet, we begin to conceive of the magnitude of the rock strata with which our study deals.

It is a common conception that the strata of Illinois lie flat. They appear to do so in many exposures whose horizontal extent is measurable in some scores of feet. But it does not take more than a slight departure from horizontality to bring about a considerable vertical rise or fall when distance is measured in miles rather than feet. If the departure from horizontality is no more than half a degree, this would amount to about 46 feet in one mile, or about 460 feet in ten miles, and about 4600 feet in 100 miles. Inasmuch as we are dealing with the dimensions of a State rather than a county or township, and inasmuch as our geologic formations are continuous over a great extent of territory, regardless of State boundaries, we should not be surprised to find that the geologic situation in one locality may be quite different from that in another.

To be still more specific, let us examine the accompanying map in figure 1 which shows the altitude of the St. Peter sandstone in the northern part of the State and as far south as we have knowledge. In northeastern Stephenson County, and in Ogle and Lee counties, the St. Peter sandstone reaches an altitude of approximately 800 feet above sea level. Southwest from the center of Lee County, the formation dips to lower and lower levels, passing successively the 600-, 400-, and 200-foot levels, and before reaching the southwestern corner of the county, it descends to a depth of 400 feet below sea level. Southeast from here, our best evidence indicates that it continues to descend, reaching 800 feet below sea level in central Bureau County, 1060 feet below sea level at Peoria, and more than 1400 feet below sea level in southern McLean County. Still

FIG. 1. STRUCTURE MAP OF THE SURFACE OF THE ST. PETER SANDSTONE

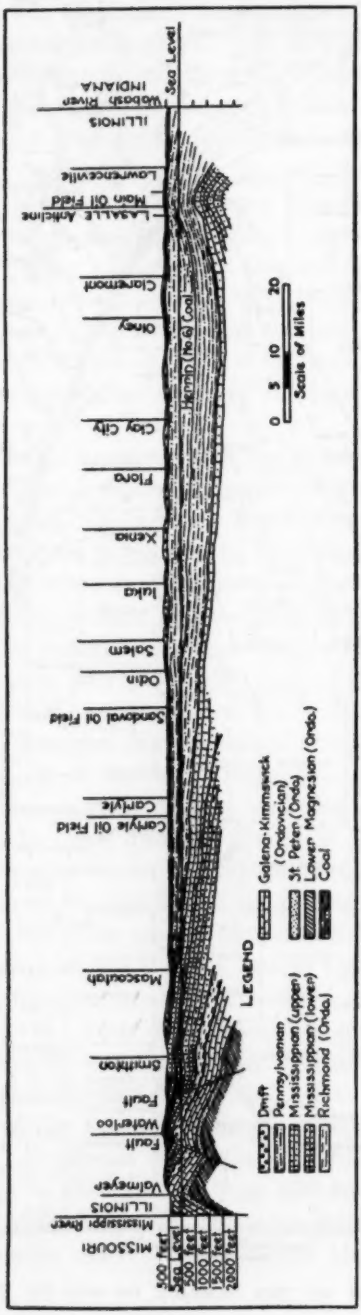

FIG. 2. SECTION ACROSS SOUTHERN ILLINOIS THROUGH MONROE, CLINTON AND LAWRENCE COUNTIES, SHOWING THE LA SALLE ANTICLINE AND THE BROAD ILLINOIS BASIN

farther south, in Perry County, the well of the Illinois Central Coal and Salt Company at St. Johns, ended at a level of about 3134 feet below sea level in the formation just above the St. Peter sandstone.

Westward in Illinois from the line just traced, the strata rise gently, but generally not reaching sea level, whereas eastward there is an abrupt rise to the crest of a fold known as the La Salle anticline which extends in a northwest-southeast direction from Lee County to the oil fields in Clark, Crawford, Lawrence, and Wabash counties. From the crest of this fold, the strata dip much more gently eastward than to the west, making the fold asymmetrical. It is to be noted that the crest of the fold declines gradually southeastward. In La Salle County, the St. Peter sandstone on the fold reaches an altitude in excess of 600 feet, above sea level, and in places underlies immediately the surface soil, whereas farther and farther south it declines to more than 2467 feet below sea level in Clark County, younger and younger formations coming in to bury it. Now changing our direction to an east-west line we note the lay of the rock formations well shown in figure 2, which is a cross-section by R. S. Blatchley, from Valmeyer on the Mississippi to Lawrenceville, near the Wabash. This figure brings out the way the formations dip in the western part of the State and the marked change which takes place at the La Salle anticline.

It is clear now that the formations west of the La Salle anticline lie in a great basin and that those strata which are a continuation of shallow strata in northern Illinois are deeply buried. The uppermost bedrock formations belong to the Pennsylvanian system and have a thickness of a few feet near the edge to 2100 feet in Clay County. Beneath the Pennsylvanian system over a considerable part of the basin the drill must penetrate the formations of the Mississippian and Devonian systems before it reaches the well-known aquifers of the Silurian, Ordovician, and Cambrian systems. What higher horizons then may be regarded as potential aquifers? Within the Pennsylvanian system the basal formation, the Pottsville, is the chief potential aquifer, but even this is doubtful, for while it is generally a sandstone formation, within short distances it may become a shale. This character, together with its small amount of voids due to the angularity of the sand grains and the presence of some clay bond, all tend to obstruct the free percolation of water and prevent it from being an aquifer of the type of the St. Peter sandstone.

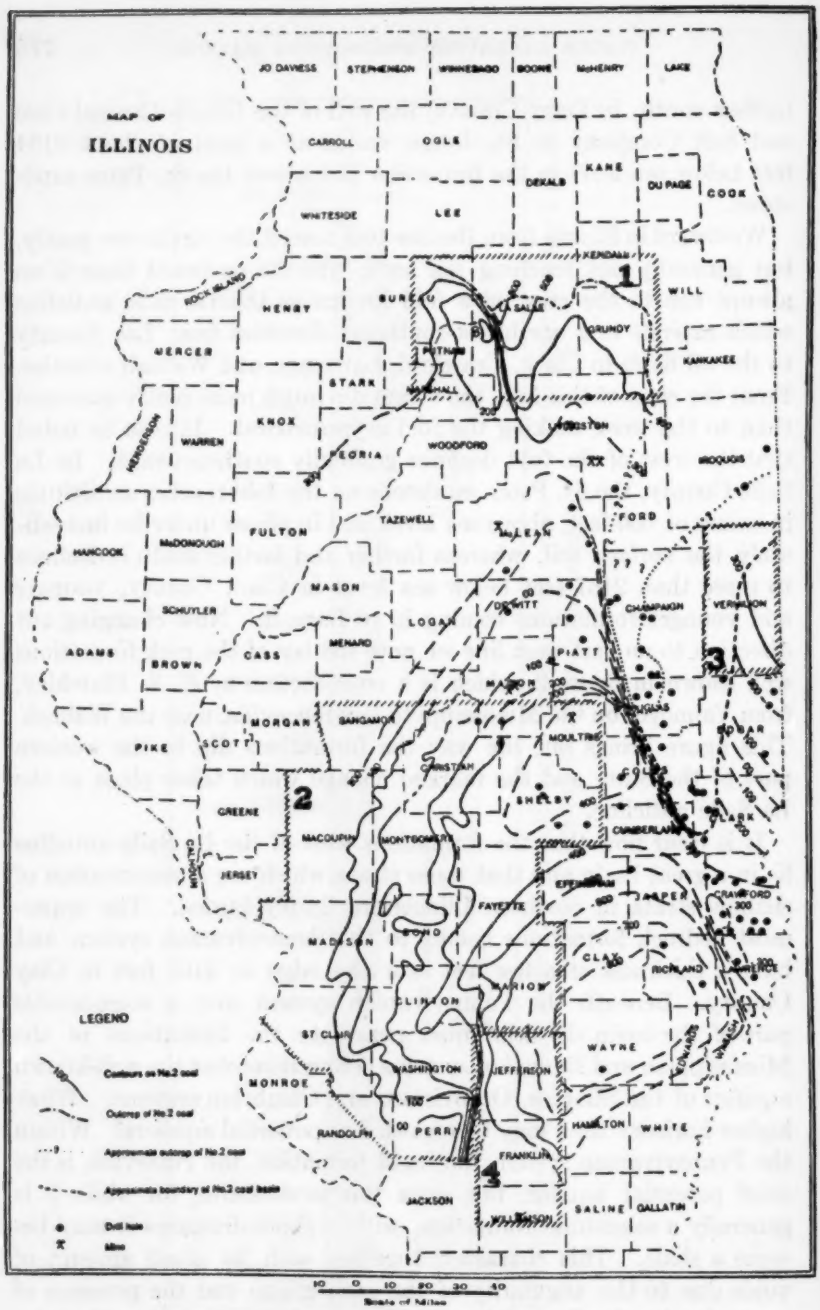

FIG. 3. STRUCTURE OF PENNSYLVANIAN STRATA ACROSS THE LA SALLE ANTICLINE, BASED UPON DETERMINED OR ESTIMATED ALTITUDE OF NO. 2 COAL

Some conception of the altitude at which the Pottsville lies may be gained from the accompanying map (fig. 3). Although the contours on this map are based on no. 2 coal which lies immediately above the Pottsville formation they may be regarded as essentially representing the top of the Pottsville. It is to be noted that from DeWitt County south the top of the Pottsville is everywhere below sea level and descends to more than 800 feet below sea level in Wayne County. While some of the Mississippian formations may be water carriers, they lie still deeper than the Pottsville.

CHEMICAL CHARACTER OF THE BEDROCK WATER IN CENTRAL AND SOUTHERN ILLINOIS

The quantity of the bedrock water and the depth at which it may be secured are only two of the important factors in the consideration of ground water supplies, the third being its quality or chemical character.

It is generally appreciated that water from the bedrock formations is never pure or free from mineral matter. In fact, there is probably no pure water in nature. But there is a considerable difference in the quantity of mineral matter which may be present in solution in the different formations and at different places, and a considerable difference in the kind of mineral matter.

Figure 4 is a map showing the locations of the various municipalities in the State which secure their water supply from rock wells. It is to be noted the greater prevalence of rock wells is in the northern part of the State. The dominant type of well in the central and southern parts is the drift well which is not shown on this map. Chemical analyses have been made of the waters of all of these rock wells, and their content of mineral residue determined in parts per million. These have been classified on the basis of quantity and so indicated on the map by symbols as given in the legend. We are indebted to Bulletin 16 of the Illinois State Water Survey for these data. It is possible that some addition to this number of wells might be made if the study were to become more intensive, but it is believed that the data at hand are adequate to show the general status of the situation.

Only 12 of the municipal wells of the State yield water with a mineral content less than 300 parts per million; 59 wells yield 300 to 500 parts per million; 60 wells, 500 to 1000 parts; 37 wells, 1000 to 2000 parts; and 14 wells yield in excess of 2000 parts. All of

those which yield less than 300 parts per million are located in the northern part of the State, excepting two, namely Mounds and

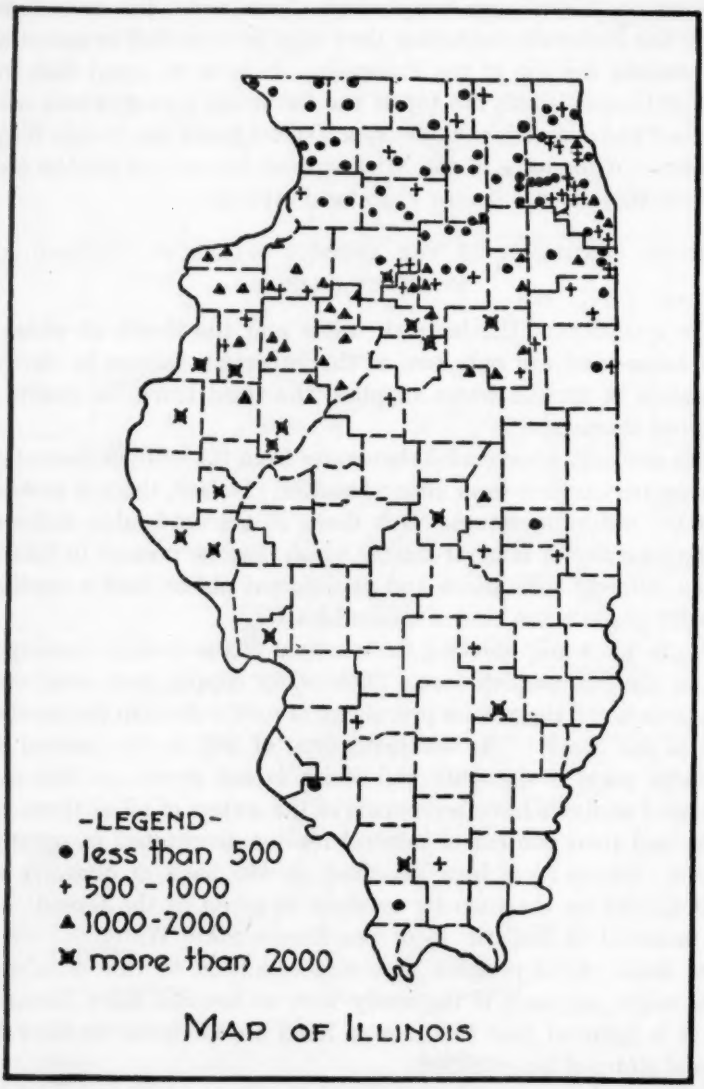

FIG. 4. MAP SHOWING LOCATION OF VARIOUS MUNICIPALITIES IN ILLINOIS THAT SECURE THEIR WATER SUPPLY FROM ROCK WELLS

Mound City which are located in the extreme southern part of the State, south of the Illinois Ozarks. None of the wells in the central

and southern parts of the State yields less than 400 parts per million, and the great majority of them yields more than 1000 parts, and at Decatur, there is a well which, according to the Illinois State Water Survey, yields 76,377 parts per million. We do not know the chemical character of the water from all of the water-bearing formations in every part of the State, and it is to be hoped that such a study can soon be made. Nevertheless it seems that the high mineral content of water from central and southern Illinois prevails without regard to any specific bedrock formation. It is, therefore, evident that drilling to the deeper horizons would be a discouraging venture, not only from the standpoint of cost, but also from the standpoint of industrial use.

WATER RESERVOIR PROJECTS

Faced with this situation, attention is being turned more and more to the development of water reservoirs, and to the treatment and use of surface water. Indeed, it appears that we are entering upon an epoch of reservoir projects. In this case, it is exceedingly important that a drainage line be chosen which has adequate runoff and which affords a natural reservoir site. Data then are required as to the extent of the area drained, the amount of slope, the steepness of slope, and the relations of such an area to sources of pollution. Where topographic maps are not available expensive preliminary surveys are necessary. In order to eliminate a large part of such expense and in order to facilitate a prompt consideration of surface water resources and plans for reclaiming the same, the Illinois Geological Survey is taking cognizance of the local needs of municipalities in formulating its program of topographic mapping. Towns which have apparently reached their crisis in respect to water supplies, and which are anticipating an early financing of a water reservoir project, are receiving special consideration in the selection of areas to be mapped at an early date.

The execution of a water reservoir project is something more, however, than a consideration of adequate surface supplies and the economic construction of a satisfactory dam to impound the same. It involves also the selection of a reservoir site after an examination that is something more than a surface inspection. The earth materials beneath the dam must be of a sort which will support the weight of the dam and will not develop weakness by virture of an incipient condition which is prone to become hazardous under the weight of

the dam and the impounded water, as time goes by. The earth materials beneath the dam, at the ends of the dam, and in the natural walls of the reservoir must also be such as to prevent excess leakage. It is well appreciated by experienced engineers that the materials which enter into a dam may be first class in every respect, the construction of the dam may be in accord with modern standards of engineering, and that the structure itself may well invite the admiration of our engineering profession, but if it happens to be placed in a geologic environment, where, by reason of lack of strength in the materials beneath the dam or by reason of an incipient defect in the rock strata, the ideal structure is bound to give way, large sums of money will be lost, and another critical demand for water attend the catastrophe. And they further recognize that, even though the geologic foundation of a dam may be strong, the primary purpose of the dam is defeated if excess leakage takes place beneath or at the ends of the dam, or through the natural walls of the reservoir.

In order to avoid such failures as have attended some water reservoir projects elsewhere, in order to prevent the possible loss of large sums of money, in order to maintain possession of an adequate reservoir supply so necessary to the health and industrial development of any municipality, the Illinois Geological Survey is prepared to coöperate to the full extent of its prescribed functions with the municipalities involved, and is ready to place at their disposal such information and facilities as it has available. It is prepared to give advice regarding the character of the preliminary tests to be made, in regard to the proper recording of the results of such tests, and in the interpretation of the data acquired. It is recognized that almost every new locality has a different set of geological conditions, and a special consideration of each is therefore imperative.

WATER WORKS AND THE FIRE PROTECTION OF SMALL MUNICIPALITIES[1]

By Charles W. Parsons[2]

Engineers in designing new water supply systems and in laying out improvements and extensions for existing systems, and superintendents in planning and supervising improvements in their own water works, are confronted with many problems. The fundamental problem is to furnish the best possible service for the least possible cost. This service should meet the requirements of both the domestic consumption and adequate fire protection.

In the small municipalities the requirements for fire protection often are not appreciated and consequently are greatly underestimated or sometimes almost entirely ignored. The average small city fortunately has comparatively few fires per year and the aggregate of high values in the mercantile district is proportionally less than in the larger business centers. These two features tend to give the citizens a false sense of security and often of indifference to the need of reliable fire protection. The domestic use of water is an almost involuntary part of the every day program in the home and place of business, and any slight irregularity or brief interruption of the usual pressure or quantity is given immediate attention and proper steps are taken to prevent a recurrence. The principal function of the water system, as casually defined by the ordinary citizen, would then seem to be the supplying of pure water in quantities sufficient for the domestic consumption. The question of providing fire protection would consequently appear to be an important, although secondary, consideration. It would follow naturally that the design and enlargement of water works should be made in such a way as to fulfill most economically and satisfactorily the requirements of this purpose for which it is apparently maintained. Engineers and superintendents, of course, comply with the wishes of the citizens and make the necessary provisions and extensions for

[1] Presented before the Illinois Section meeting, March 19, 1924.

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maintaining the best possible service to the consumers, with the funds available. Whatever surplus money and equipment can be obtained is put to its best use for improving the ability of the water works for furnishing fire protection to the community.

In spite of this popular conception of the relative importance of the dual functions of a water system, the fire flow necessary to control properly larger fires in mercantile districts is from five to twenty five times the domestic consumption in the same city. This ratio of required fire flow to domestic consumption is greater for the smaller cities and presents a difficult problem to the municipality which desires to provide a reasonable amount of protection for the safety of life and property from fire.

It is the aim of this paper to point out briefly a few ways in which a water supply system may be materially strengthened at a minimum cost, to furnish more adequate and reliable fire protection.

The cities of Illinois, as well as those in many other states, are classified according to the value of their fire protection as measured by the requirements of an engineering grading schedule prepared by the National Board of Fire Underwriters, from the practical experiences of fire protection engineers, water superintendents and fire chiefs. Under the provisions of this schedule definite quantities of water are prescribed for the adequate protection of cities of different sizes and corresponding standards set for each part of the water works through which these quantities must be passed to reach the fire. The proportion in which these requirements are met is the measure of the quality of the protection afforded by these facilities, and is the means of arriving at the insurance classification of the city.

Each of the several component parts of a water supply system is measured with respect to its adequacy or normal capacity to furnish the domestic consumption, plus the required fire flow. These are compared to determine which is the weakest part, or the limiting feature, of the entire system and the one which should first be improved. A similar analysis is made of the reliability of each part of the system or the capacity remaining after a break has occurred at the most critical location. The distribution system is carefully studied and actual tests are made to ascertain if the size of the main arteries, the secondary feeders and the pipe in the gridiron is sufficient to provide the necessary amount of water to each section of the city. The location, size and condition of hydrants is investigated to determine the ease with which the necessary quantities of water may be

thrown on a fire in any building. Many other parts of the water supply system are thoroughly studied and graded with respect to their ability to fulfill properly their particular function as a fire fighting facility.

In the continual application of this grading schedule to various types of water works, it is surprising to note the frequent recurrence of the same points of weakness. Four suggestions will be briefly outlined for strengthening those points which are of the greatest relative importance. Such improvements will materially increase the adequacy and reliability of the fire protection which can be furnished by a water works to a small municipality.

Greater suction storage capacity is probably the most important of these four considerations. Storage lessens the requirements of those parts of the system, through which its supply has already passed. Thus, greater suction storage for the high lift pumps reduces the necessary well yield, filter capacity and low lift pumping capacity, for maintaining the full required fire flow. The source of supply should be developed to such an extent that the well yield or the minimum stream flow, the low lift pumping capacity and the filter capacity should be as great as economically possible, and at least several times the maximum domestic consumption. Only such quantities as are in excess of the maximum rate of domestic consumption would be available at the hydrant for fire fighting. Since the required fire flow is from five to twenty-five times this domestic rate, it is often prohibitive to provide additional wells or corresponding sources of supply to furnish all of this additional quantity. The grading schedule prescribes that the required fire flow shall be available throughout a ten-hour period, or in very small cities a five-hour period. These requirements, therefore, would be fulfilled, for all portions of the supply works up to the high lift pumps, by a suction storage reservoir, which together with the source of supply would generally be much less expensive than providing deep well pumps and filters of sufficient capacity to carry the greatly increased load necessary properly to control large fires. The investment in the construction of a covered surface reservoir of sufficient capacity for this purpose would enable a great many of the small cities to obtain much more adequate and reliable fire protection.

High lift pumps should have a total capacity in excess of the sum of the domestic consumption and fire flow and should be properly

arranged to pump from the storage reservoir as well as from the normal source of supply. This high lift capacity may likewise be reduced in proportion to the quantity which has passed these pumps and is available from elevated storage at the required fire pressure. Credit can be given for this elevated storage only at the rate at which it can be uniformly depleted over a ten-hour period. Unless the topography of the city makes elevated reservoirs possible, the cost of standpipes and elevated tanks greatly restricts their size so that beyond certain limits additional pumping capacity is cheaper than larger tanks. The capacity of the supply mains must likewise be equal to the requirements, to assure the adequacy of all portions of the water supply system.

Reliability or duplication is the second point for consideration. Pumps and all piping and supply mains should be so duplicated that no single break could cut-off the supply to the built-up portion of the city. All pumping stations, regardless of the size of the city, should have at least two high lift pumps, so that a substantial supply can be furnished while either pump is undergoing necessary repairs. Each pump should have an individual suction from the storage reservoir with connection to the normal source of supply. The discharge header should be so arranged and gated that no single break or repair of a valve would place more than one pump out of service. This would require two gates in the header between each pump. Two supply mains of adequate size should extend into the distribution system and should preferably enter the mercantile district from opposite sides. The pumping station should be entirely of fire resistant construction and all internal hazards should be properly safeguarded in order to minimize the liability of an interruption of service by fire.

Many water works have been found which have two or more pumps and more than one supply main to the distribution system, and yet have a common discharge header, the repair of which would cause a shut down of the entire pumping station and the total interruption of the supply to the city. This is a very important consideration in the design of new plants and often an easy means of materially increasing the reliability of existing supply works.

In the majority of the smaller cities of this state the pumping station is located within a reasonable distance of the closely built portion of the city and in many instances is within a few blocks of the mercantile district. In most of these cities the cost of a second

supply main of adequate size would be more than offset by the substantially increased capacity of these mains under normal conditions, and by avoiding a total interruption of the supply in case of a single break in either line. Where the duplication of the single supply main is not economically feasible, it is often inexpensive to extend a moderate sized feeder from the pumping station to the nearest point of the distribution system. Such a connection will enable a limited quantity to be supplied to all portions of the city while repairs are being made on the principal supply line. These provisions for duplicating each part of the water supply system and for the installation of sufficient valves to prevent any single break from resulting in an interruption of the supply are most important to the health and convenience of the citizens and are even more essential to the safeguarding of life and property against fire.

Our third consideration will be 4-inch mains. It might seem rather unnecessary to dwell upon this familiar subject again, when so much has been said against the installation of this small pipe in fire protection systems. In spite of the acknowledged fact that 4-inch mains are entirely too small for this service, a surprisingly large amount is being installed every year and especially in cities of the size that we are discussing. The most common excuse is the apparent lower cost. A second argument is that portions of the city supplied through this undersized pipe will probably not grow to require quantities in excess of its capacity.

Ample theoretical data and results of innumerable tests are readily available and no attempt will be made here to point out the degree to which the capacity of a fire protection system is limited by the excessive friction loss in 4-inch mains. While the cost of 6-inch pipe is somewhat greater than 4-inch, the cost of laying is nearly the same and the capacity is nearly three times that of four inch. When original installations are entirely of 6-inch mains, with 8-inch feeders at frequent intervals, a material growth of that portion of the city may occur before it will be necessary to provide larger arteries. On the other hand when 4-inch mains are laid because of the existing low consumption in newer districts, it will be necessary to replace a considerable amount with 8-inch or larger pipe as soon as the city has been built up and the increased domestic consumption and fire flow require a materially stronger arterial system. The best engineering and economic solution of that problem is to follow the practice of many progressive cities and use nothing smaller than 6-inch pipe.

Our fourth and last consideration is the location, size and condition of hydrants. The proper spacing of hydrants is determined by the fire flow required for the district being protected. Sufficient hydrants should be located within such a distance of any group of buildings, that this required fire flow may be thrown on the fire with the necessary nozzle pressure. The high friction loss in fire hose limits the efficient lengths of such lines to two or three hundred feet, at the pressures usually available at the hydrant. The small mains often found in smaller cities usually make it impossible to obtain more than two standard hose streams from a single hydrant. Where the fire department is equipped with automobile pumpers, quantities up to the capacity of such pumpers, if available at the hydrant, may be forced through longer lines and be thrown on the fire at a higher nozzle pressure. Under such conditions satisfactory streams will be available within a greater radius of each hydrant. The spacing of hydrants is commonly referred to in terms of the average area served per hydrant. The allowable area served per hydrant varies from 40,000 to 100,000 square feet depending upon the protection required, and usually proportionally with the decreasing size of the city. This area is greater in cities provided with automobile pumpers.

Hydrants should have at least one 4½-inch outlet, two-2½-inch outlets, a 6-inch barrel, 5-inch foot valve and a 6-inch gated connection to the street main. Hydrants in many of the smaller cities unfortunately fall short of this standard in several respects and materially decrease the adequacy of the water supply system. The installation of hydrants with an undersized barrel and foot valve is gradually being discontinued, but the use of a 4-inch connection to the street main and the omission of valves in this connection is still being followed in numerous small cities. The friction losses in the undersized branch and barrel under a heavy fire flow are excessive and are an unnecessary burden on the other parts of the water works. The cost of individual valves for hydrant branches is more than offset by the ability to repair or replace a hydrant without the necessity of shutting off the supply from several blocks, or where the valve spacing is poor, from a considerable portion of the city. The popularity of the automobile pumper, even in the small cities, makes it good practice to install hydrants having a 4½-inch outlet, even where such a pumper is not actually in service. Where it is not feasible to replace entirely the existing small hydrants, those

near the mercantile and other high value districts should be replaced, or at least removed to outlying sections, and proper sized hydrants with a 4½-inch outlet installed, so that the required large quantities will be available for the control of serious fires.

Hydrants need a fair amount of attention. They should be inspected in the spring and fall of each year, after being used at fires and daily in closely built districts during freezing weather. A large investment in equipment and the efficient operation of all parts of a water works may have been largely in vain if a hydrant has been neglected and fails to perform its function at the critical moment.

In conclusion, we shall name again the four suggestions which have been outlined for strengthening those parts of a water works that have such an important part in providing adequate and reliable fire protection for the small municipality.

1. Substantial suction storage for the high lift pumps is an economical method of providing a supply to meet the demands of a heavy fire flow for a prolonged fire. If the normal capacity of wells, low lift pumps and filters is considerably in excess of the maximum domestic consumption, the necessity for further increasing their capacity several fold may be offset by this storage.

2. The duplication of pumps and supply mains and the proper valving of suction and discharge headers is necessary to assure the reliability of the supply system. Careful arrangement of piping at the pumping station, the construction of the station and the installation of a second supply main to the closely built portions of the city are profitable insurance against the interruption of the supply at the time of a serious fire.

3. Four-inch mains are a detriment to a water system. Installation of this size of pipe is expensive, as large feeder mains must later be installed at frequent intervals to provide sufficient quantities for the protection of the city from disastrous fires.

4. Hydrants should be of sufficient size, frequently spaced and in proper condition. The failure of a hydrant adequately and instantaneously to perform its function defeats the principal purpose for which a water works is constructed and maintained.

DISCUSSION

L. R. HOWSON:[3] I think this has been a very good presentation of the protection requirements of our water supply systems. I think all of us realise that our systems are deficient in fire protection capacity, but there is another side to it from the standpoint of the privately owned company at least. The privately owned company in a town of 20,000 to 25,000 population finds that 50 per cent of its investment is required for fire fighting purposes and they find it impossible to get more than 10 to 20 per cent back in the way of revenue. It seems to me that is not fair to the water works company. The people wish the benefit of fire protection and I think it should be up to them to pay for it. This is not any argument against fire protection. We must have it.

F. C. AMSBARY:[4] The Champaign and Urbana Water Company supplies water to the city of Champaign and Urbana. The value of the plant at the present is about $1,000,000.00. Our revenue is about $150,000. Therefore, according to the speaker's figures we should receive 40 per cent of $150,000, or $60,000 per year, for fire protection. As a matter of fact we are getting about $14,000. This is not a serious matter to the water company where it has state regulation. The state commission fixes the rate of return upon the value of its property, so it matters little to the Company if 10 per cent of its revenue comes from fire hydrant rentals and 90 per cent from its private consumers, but it is not fair to the consumers.

Hydrant rentals should be high enough to cover the cost of the service and should be paid for by taxation. In this way the property that is protected will pay the cost.

We have a number of cases where large property owners require the tenant to pay the water bills. In these cases the tenant is paying a large part of the fire protection on the building in his water bills, because the hydrant rentals are below the cost of producing the service and the rates to private consumers must be high enough to make this up. State commissions recognize this and in many instances have raised the hydrant rental to somewhere near what it should be. No doubt, in time, they will correct this generally.

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[4] Manager, Water Company, Champaign, Ill.

FINANCING WATER MAIN EXTENSIONS[1]

By H. F. Blomquist[2]

The function of a public water works is to furnish various services to the inhabitants of the community in which it operates. The total cost of furnishing these services must be paid by those who receive them. This applies to municipally as well as to privately owned plants. In order to make equitable charges for the different classes of service furnished, such as water for domestic, industrial, fire protection and other public uses, the costs are analyzed into their various elements, and one of the large elements is an overhead, or fixed, expense due to the large investment in the distributing system or pipe lines for bringing the water from the source of supply to the consumer, who may be many miles away.

There are some fundamental differences in the methods that may be used in dealings involving financial matters by municipally and privately owned utilities. This paper will deal with the problem of financing water main extensions by municipally owned plants.

The pipe system may be divided into two main classes, the distributors and the feeder mains. The distributors are the gridiron arrangement of small mains, usually six or eight inch pipes serving the individual fire hydrants and blocks of consumers located along its various lines. The feeder mains are the large pipe lines which conduct water from its source to the various sections of the city to supply the distributors.

The distributors are of value only to the abutting property owners whom they serve with water and to whom they furnish fire protection. In general, an extension of distributors does not add to the usefulness of the water system, except as a means of serving the particular owners who may make connections with them. In other words, they are set apart for the use of a certain group of individuals, and can not be used by any other group. In this respect, they are different from all other parts of a water system. The source of supply,

[1] Presented before the Iowa Section meeting, October 25, 1923.

[2] Superintendent, Water Works, Cedar Rapids, Iowa.

pumping machinery, purification plant, etc., serve all consumers in common as the needs may be, and improvements or additions to them are equally valuable to all people served by the water system, but this is not so with improvements or additions to the distributors.

The pipe system of a water works represents from one-half to three-fourths of the total investment in the plant, and the small pipes, or distributors, represent the greater portion of the ordinary pipe system. An increase of 100 per cent in the cost of water main construction in a short time, together with an increasing demand for water main extensions in rapidly growing cities, have made the financing of them a major problem, especially in Iowa where there is as yet no authority for financing them by frontage tax, or by special local assessment against the benefited property.

Because of the large investment necessary in distributors, and recognizing the fact that they serve only a certain group of individuals, most of the States have passed statutes, which are upheld by the Courts, that permit municipally owned water works to charge all or a portion of the cost of such extensions to that group. A common practice in those states is to make extensions upon petition of the owners of a majority of the abutting property, and make an annual assessment of usually from 5 to 10 cents per front foot of abutting property for a period of ten years. Another method used is to make direct special assessment of from two-thirds to the total cost of the extension and certify for collection in yearly installments according to the governing laws. The details of the plans are left for each municipality to work out according to its own preferences.

There are several advantages of the special assessment, or frontage tax system, for financing main extensions, among which are the following: Extensions can be made into new and sparsely settled territory without loss to the water department, and people who would otherwise not be able to get the benefit of public water service may have it at a nominal expense, usually much less than any other water supply would cost them. Parties interested in opening new additions can have extensions made without being obliged to guarantee incomes, or pay interest on the investment in a direct way, or to put in water mains at their own cost.

Where special assessments, or frontage tax is not permitted, water departments have resorted to various other methods of dealing with main extensions. Some cities make extensions under contracts with owners of property, by which the owners guarantee an annual

income of a certain percentage of the cost of construction. Others require the land owners to make the extension at their own cost, and when a sufficient number of connections has been made and the revenue equals a certain percentage of the cost, the water departments will take the extension over at construction cost, or valuations to be made according to contract stipulations. These systems have worked fairly well, where ownership of property is vested in one or two parties, but, where lots have been sold to individuals, this arrangement becomes difficult and cumbersome and can rarely be used.

Whether a system of assessment of costs in main extensions is followed by which a portion of the income for water service is derived, or whether some other method is used, the fundamental principle remains that the consumer must eventually pay all costs of the service. There are, however, some decided advantages in one system over another, due to differences in business procedures necessary to provide the required funds. Where no form of assessment or tax for mains is used, all the costs of extensions must come in the form of water service charges. Since the outlay in mains is necessary long before income from them is available, the department must resort to the issuing of bonds or other form of indebtedness for carrying the investment until returns from the same will be sufficient to liquidate them. Frequent issues of bonds are undesirable, are often hard to bring about where popular vote is required, and are more costly than the more direct way of partially paying as you go. On the other hand, when charges are made in one form or another as soon as mains are laid and services available, the financing of extensions becomes greatly simplified.

It must be considered, however, that, if a part of the income is derived from assessment or taxes, the rate for water sold should be correspondingly lower. One is simply a method of dividing the cost of service into two parts, one of which is payable as soon as water service is available, and may be considered as a ready-to-serve charge, and the other part when water is actually used. Courts have sustained ready-to-serve charges in public utilities other than water service, but the principle involved is the same whether it is water, gas or electricity. From the viewpoint of moral justification for such division of charges, it may be stated that the actual difference in sale value of property before and after water is available is generally much more than the amount of assessments or other form of ready-to-serve charges.

Some just objections to making a change from a non-assessment system to the other might be raised on the grounds that owners of property along which future mains are to be laid will be required to pay more for water service in the form of assessments or frontage taxes than owners where mains were laid before who got them without any extra expense. These differences would not be great, however, and are offset to some extent by the older consumers having paid a greater portion, in some instances at least, toward the purchase or building up of the water plant.

In order to simplify the financing of water extensions, and yet to overcome objections to an abrupt change from a method of no assessment or charges to one which involves special assessments or taxes, a proposed law was introduced in the Iowa legislature at the last session, but failed to pass, which provided for assessments against the benefited property in an amount equivalent to the cost of a 6-inch main, but with this difference from the ordinary methods: after a property owner had made connection to the mains and had become a regular consumer, the amount of assessment paid would be refunded to him. This method would simply throw the burden of carrying the investment of water mains in unproductive territory upon the property owner until he would require water service. This principle can be defended on the grounds that the property would be increased in value after water is available fully to offset the expense of carrying the investment. In reality it would be only a ready-to-serve charge for the assurance of being able to have water service, which would be of actual value to the property owner.

Based upon experiences with the problem of financing extensions under both methods, it is the writer's opinion that the ready-to-serve charge or assessment plan for municipal water works meets the requirements much better because it distributes the cost of service more equitably and makes it possible to meet the needs of water service extensions much more readily.

THE USE OF BALANCING RESERVOIRS IN WATER DISTRIBUTING SYSTEMS[1]

By J. E. Phillips[2]

Balancing reservoirs have an everyday name in Los Angeles. We call them kickback tanks, a self-explanatory name. That is just what they are. They fill up with water at night and kick it back out the next day. The principle of their action is not new. Any reservoir placed at the end of a water main farthest from its source of supply acts as a kickback tank.

By its use a main trunk or feeder line supplying a water distributing system along its length is made to work twenty-four hours a day instead of fourteen or fifteen hours as is usually the case when not double headed by reservoirs at each end.

The twenty-four-hour pressure gauge charts of the circular type, clocked on a water main having a reservoir at one end only, almost invariably resemble the cross-section of an egg along its major axis. This is due to the fact that during the hours from 6:00 a.m. to 9:00 p.m. the draft on the main is heavy and the resulting pressure is low, thus forming the small and pointed end of the egg. The larger and more rounded end is formed during the somewhat shorter night period of low consumption and corresponding high pressure in the main.

Let us assume that our trunk line has been designed to care for only a moderate increase in consumption. Then suddenly, as quite frequently happens, and especially so in California cities, it becomes burdened with an abnormal and unexpected demand upon its capacity. Inspection of our pressure charts show that the pointed end of the egg is becoming shorter and flatter and may in extreme cases become concave at the points of peak load. Our patrons begin telephoning, complaining of poor pressure and insisting that we do something to relieve the annoying and unsatisfactory condition.

[1] Presented before the California Section meeting, October 25, 1923.

[2] Assistant Engineer, Bureau of Water Works and Supply, Los Angeles, California.

Our first thought, of course, is to enlarge our trunk line and we at once begin making estimates of costs. The existing main may be a perfectly good cast iron pipe, capable of giving many more years of service. The cost of enlarging or paralleling it may mean the expenditure of thousands or even hundreds of thousands of dollars, depending on its size and length. In water works, the same as in any other business, the financing of enlargements and betterments is an ever present worry. Engineers are constantly faced with the necessity of building their works not more cheaply, but more economically.

With this aim in view we endeavor to find some means of prolonging the usefulness of our trunk line without expending too much of our funds. We again consult our pressure charts, but instead of viewing with alarm the ever increasing flatness of the small end of the egg we discover that there has been practically no change in the large rounded end and we ask ourselves if that nine- or ten-hour period cannot be made one of work instead of rest for our trunk line.

If from our charts, which have been made at several points along the length of the main, we plat hydraulic grade lines for different times of the twenty-four-hour periods, we find that during the periods, 6:00 to 10:00 a.m. and 5:00 to 9:00 p.m., the hydraulic grade lines have a very marked downward slope throughout the entire length of the main, and, in extreme cases, may almost reach as low as the main itself at the end farthest from the reservoir or source of supply. During the night, however, from 9:00 p.m. to 6:00 a.m. the grade lines will extend nearly horizontal from the water surface in the reservoir at the head of the main. In other words we have static pressure. The main is idle. Plenty of water but no place for it to go. Here then is a tentative solution of our problem. Provide a place at the end of the main for the water to go during the night hours so as to be ready for use bright and early the next morning, at the points where it is most needed. Build a reservoir or tank. And, fortunately, it does not have to be large. A small one is usually sufficient.

It is well to remark here, of course, that this solution of our problem is not always possible. The topography of the ground may not permit a tank to be built at the proper elevation. The main may be so extremely small in proportion to its duty as to make its enlargement imperative. In many instances, however, the principle of the kickback reservoir may be utilized very economically.

If, in the further study of our problem, we conclude that conditions are right for the construction of such a reservoir, the next step is to determine the elevation at which to build it and the size. These two factors are a function of each other, and both are dependent upon the capacity of the main and the length of the period during the night when water will be flowing into it. In Los Angeles it is common practice to locate the reservoir at such an elevation as will provide a friction head of about 30 feet in the main.

By taking a series of twenty-four-hour pressure gauge readings on the main, we determine the average length of the period during the night when the main is idle. With a friction loss of 30 feet—or whatever allowable loss we may adopt as practicable—it is a simple problem of hydraulics to compute the amount of water which will flow into the reservoir during the idle period at night. The proper size of reservoir is that which will contain—or slightly more than contain—this amount.

Such a reservoir, properly designed, will alternately fill and empty each twenty-four hours and if hydraulic grade lines are platted under the new conditions, we will find that, instead of sloping uniformly downward as before, they will assume more the position of a suspended cable or catenary, almost as high at the outer end of the main as at the head. Now the main is performing useful work twenty-four hours a day. Complaints of poor pressure and lack of water cease coming in. We breathe easily once more and feel justly proud of our accomplishment.

Speaking briefly of the success of such reservoirs in Los Angeles, I will say that they have not only been money-savers, but have enabled us to keep pace fairly well with the unprecedented growth of the City. Fortunately the topography in our vicinity is adaptable to their use. High towers are unnecessary. For domestic use our practice is to construct riveted steel cylindrical tanks which permits of quick and reasonably cheap construction. An altitude valve or pressure regulator is placed in the main near the tank which automatically shuts off the flow into the tank when filled. The capacity of the tanks is usually from 300,000 to 600,000 gallons. One, however, located at the southerly terminus of a 36-inch main, eight miles in length, on Western Avenue, is 150 feet in diameter, 50 feet high and has a capacity of about seven and one-half million gallons. Its elevation is such as to allow about 80 feet friction head in the main. It is, also, of riveted steel construction and was built

in 1917. This tank has fulfilled its purpose exceedingly well and is still doing so in spite of the increased demands made upon it. Its construction, which cost about $90,000.00, obviated the necessity of duplicating this eight-mile line of 36-inch pipe, the cost of which as you can readily see would have been many times the cost of the tank.

We now have under construction a reservoir on the southerly side of the San Fernando Valley whose function in the irrigation system of the valley is the same as the steel tanks in our domestic system. It will have a capacity when completed of 3100 acre feet and is situated at an elevation of about 100 feet below, and works in conjunction with, the large San Fernando Reservoir on the northerly side of the Valley. This reservoir, known as the Encino Reservoir, was in operation last year, and the results obtained, even in its uncompleted condition, were very gratifying. It will not only take care of the daily fluctuation in service, but is large enough to provide considerable storage for the summer use.

A COST SYSTEM FOR WATER WORKS IN LARGE TOWNS AND SMALL CITIES[1]

By Erle E. Peacock[2]

During the past decade there has been so much interest created in the reduction of costs that a number of states have taken steps to make comparisons easy by requiring uniform accounts for the different water systems. By 1919, water works commissions had established uniform systems in fourteen states. While most of these have been general systems, still they have enabled the managers of the various plants to compare expenditures and remedy deficiencies. These comparisons are so valuable in any attempt to reduce costs that it is surprising that so few states require uniform accounts. It is to be hoped that a cost and not a general accounting system will be required by those states which attempt it in the future. While many general systems give much valuable information, a cost system will produce greater efficiency and more intelligent rates.

Cost systems distinguished from general systems show unit costs. A general accounting system would show all of the different expenses, sources of income and the net profit or loss, but would not attempt to secure the cost of production of each thousand gallons of water and the unit costs of the different processes such as the collection, purification and distribution of the water. A general system would give you the total cost of repairs, but a cost system in addition would distribute this cost over the different processes.

DESCRIPTION OF THE SYSTEM

An attempt will be made to outline for the reader what is considered a desirable cost system. It seems that what is termed a process system would fit a water works. First the plant should be divided into departments or processes and a unit of measure

[1] Presented before the North Carolina Section meeting, November 15, 1923.

[2] Professor of Accounting, University of North Carolina, Chapel Hill, North Carolina.

established. It would appear that the following divisions would prove to be the most logical and natural ones for a small plant: (1) Collection, (2) Purification and Chemical Treatment, (3) Distribution. These may be further subdivided. It is usually desirable to secure the costs of chlorination, which is included as a sub-division under Purification and also Storage and Pumping costs which are included as sub-divisions under Distribution. As in a general accounting system, however, all of the costs of production such as labor, material, fuel, etc., are determined, but they should in addition be prorated over the three divisions or processes, thereby securing the entire cost of each. This would make necessary time tickets and material requisitions so that labor and materials may be correctly charged to those processes which use them. Labor and material would both be used in different amounts by all of the departments. The material should of course be properly stored, and accounted for when purchased and issued, by store record sheets, which would give a perpetual inventory.

DISTRIBUTION OF EXPENSES

The entire cost of the superintendent's office, including his salary, should be secured and prorated over the three processes on a time basis. Repair costs should be summarized in an account and distributed on the basis of the actual work done for each department or process. Depreciation and interest on investment computations are made from the property records of each department and distributed accordingly. All costs in connection with the chlorination of the water, such as labor, depreciation of the meter and equipment and cost of commercial chlorine should be determined and charged to the "Purification and Chemical Treatment Process." All pumping expenses and storage costs should likewise be summarized and charged to the "Distribution Process."

Since purified water is used in cleaning filter plants and water mains, it is necessary that the total cost of the purified water be determined. Therefore, all collection expenses and purification and chemical treatment expenses are transferred into an account called cost of purified water from which can be secured the cost of all water used for cleaning purposes.

Since the cleaning of water mains is done at irregular periods, part of the cost should probably be deferred to other accounting periods. For instance, if the books are closed and costs are secured

every month and the mains are cleaned only once every twenty-four months only $\frac{1}{24}$ of the cost of cleaning should be charged each month to "Distribution." It is necessary, therefore, to carry a "Water Main Cleaning Account" to which is charged all cleaning expenses so that the cleaning expenses prorated to the current month may be transferred to the "Distribution Process Account" and the remainder deferred for charges in future months. All irregular expenses of this kind should be similarly treated.

After all expense accounts have been distributed to the three processes and collection and purification expenses transferred to the Purified Water account the total cost of manufactured water for the month is secured by transferring the "Cost of the Purified Water Account" and "Distribution Process Account" to an account entitled "Cost of Distributed Water" which will include all of the costs except general administrative and selling expenses. The balance of the "Purified Water Account" at this stage should represent the cost of water in the storage basins. Since all water collected and all sold is metered, the amount of gratuitous water and water wasted can be secured. This is charged to the "Distribution Process Account." To the cost per 1000 gallons of distributed water should be added administrative and selling expenses to arrive at the selling price per 1000 gallons. This selling price should furnish funds enough to pay all of the operating expenses, including interest on investment, and administrative and selling expenses. A great many cost accountants are opposed to adding interest on investment to manufacturing cost of goods produced, but in a water works system it seems to be necessary, since water is sold to the consumer on a cost basis and funds must be secured to pay interest on the bonds issued for the purpose of providing plant and equipment. The inclusion of interest on investments in operation costs will also enable managers to compare fairly the different kinds of equipment and thereby use the most efficient.

SPECIAL TRANSACTIONS AND ACCOUNTS

So much has been written relative to the distinction between capital and revenue charges that it hardly seems necessary to mention the fact that all expenditures for and on account of construction work and the installation of equipment, the use of which will extend beyond the current accounting period should be charged to an asset account, and the total cost in the form of depreciation

charges distributed over the life of the property. It is now an established procedure in water works accounting to charge all expenditures for construction work to an account entitled "Construction Work In Progress" and when the work is finished to transfer it to fixed capital accounts.

It is always a difficult matter to determine accurately the cost of operation caused by obsolescence and "wear and tear" of property. The straight line method of depreciation, however, appears to be the best because the per cent loss in value is approximately the same each year and it is the simplest and easiest to apply. Therefore it is the most frequently used. The rates ordinarily found, according to Will. A. Clader in an article in the *Journal of Accountancy*, August, 1919, are:

> Large reservoirs 1 per cent; small reservoirs 2 per cent; cast iron pipe 1 per cent; wrought iron pipe 2 per cent; wood pipe 2 per cent; stand pipe concrete 2 per cent; stand pipe wood 3 per cent; valves 2 per cent; hydrants 2 per cent; meters 4 per cent; pumping equipment 4 per cent; steam engines 4 per cent; boilers 5 per cent; electric generators and motors 4 per cent; filter plant 3 per cent; buildings 2 per cent; laboratory equipment 10 per cent.

It has been brought to my attention that in most cases water is gratuitously furnished to the municipality and its schools, passing the burden of this gratuitous water to the charge consumers. This seems wrong in theory for the schools and the municipal government belong to all of the citizens and there is no reason why any part of their up-keep should be borne by a special class and distributed to them in the ratio of their consumption of water. Then for accounting reasons each department of the city should be kept separate, receiving all charges due and credited with all services, just as if it were an outside concern so that its efficiency may be determined and its management rated. This means that the water works plant should be taxed and the tax charge distributed to the operating divisions and all water furnished the city should be metered and paid for. Eliminating gratuitous and unmetered water would also enable the management to account more closely for water lost in distribution and probably it would be able to curtail this loss to some extent. In this connection it might also be stated that accounts should be kept showing the additional expense to water works for fire-fighting apparatus such as high-powered pumps and like equipment.

COST REPORTS

Illustrative forms of reports that can be prepared from your cost accounts may be found in exhibits A, B and C. Exhibit A is a cost statement for the plant as a whole, showing for each process total costs and the cost per 1000 gallons of water manufactured for the current month, for the same month last year and the total cost to date for the current accounting year compared with the same period last year. This statement is supported by a similar one for each operating process in which the costs are itemized and compared (exhibit B). A third group of statements will be those showing itemized comparisons for the more important expense accounts such as pumping, chlorination, storage and operation management, illustrated by exhibit C.

Budgetary accounting has recently become popular. If estimates are made at the beginning of each accounting period as to future requirements and costs, and budgets for the current period prepared from these estimates, it would probably be better to include in the comparative columns one for the budget estimate rather than "cost to date column for the preceding year," for every manager should attempt to stay within his budget allowance.

It is beyond the scope of this paper to discuss the accounts in detail and the forms necessary for the operation of the system. It might be stated, however, that the usual books of original entry would be required and in addition such forms, as purchase requisitions, material received reports, stock record sheets, material requisitions, time tickets, payrolls, and reports of meter readings. Exhibit D shows a typical set of accounts and by means of numbers indicates the debits and credits for the operating cost accounts.

ADVANTAGES OF A COST SYSTEM

Of course a cost system will entail more records and, therefore, more time and expense. Its advantages should be, therefore, of such a nature as to far outweigh any additional cost. The benefits usually derived from such a system as described in this article are as follows: A good system will enable the manager to have prepared accurate cost reports from which he can secure the necessary information to determine the correct water rate for the consumer, something which is continually in dispute. Furthermore, he will be able to support his rate by accurate cost statements which may be

published, making it easy for him to show why the local rate differs from those of other cities. If costs are excessive he will be able definitely to locate the trouble and probably to remedy it. If costs have increased on account of some uncontrollable force, as a rise in the cost of materials, it will be discovered and he will be able to answer satisfactorily any criticism made of his management. Occasionally new meters and purification, distributing and collection equipment will be invented and offered for sale. In order to determine whether these new processes and new equipment should be installed or not, the question of cost of operation must be considered, for that, of course, is the most important consideration. This comparison of cost of the operation of the new equipment with that of the old is possible only through the use of cost systems. Any misappropriations or waste of materials and supplies will be discovered by a comparison of the perpetual inventory, as shown by the store record sheets, with the physical inventory taken at intervals. A check on the efficiency of labor can also be secured from the time tickets and labor records. Responsibility for improper handling of materials and processes of manufacture can therefore be definitely determined and inefficient employees discharged. A cost system may in addition be used as a basis of standardization. The cost used as a basis in fixing selling prices should be the standard cost of normal production, rather than the abnormal. The most efficient method and economical hours of operation may also be determined through comparative costs. For instance, it might prove to be the most economical to have all of the pumping done at one time or at certain hours of the day. Comparisons for different periods of the costs and income of the whole plant and the sub-divisions such as collection and purification of water can be made which will aid in formulating future policies.

CONCLUSION

Is the system too complicated and burdensome for the ordinary town? It is admitted that for very small plants the system here briefly described would probably be too elaborate, but it probably could be adjusted to fit any plant. The same principles would be involved. In fact in every plant different conditions will be found and no system could be planned which would fit all of them; probably in every case some change would have to be made. Of course, in the smaller plants there would be fewer departments, a smaller number of accounts and longer accounting periods covered by a smaller number of reports.

EXHIBIT A

Chapel Hill Water Works

Cost of Water Statement—June, 1923

	MONTH OF JUNE	COST PER 1000 GALLONS	SAME MONTH LAST YEAR	COST TO DATE	COST LAST YEAR TO DATE
Cost of Collecting Water.....					
Cost of Purifying and Chemically Treating Water.....					
Cost of Distributing Water. ...					
Franchise Dues.....					
General Administrative and Selling Expenses.....					
Financial Expenses.....					
Total.....					

Total water pumped ——— gallons.

_____

Signed

EXHIBIT B

Chapel Hill Water Works

Cost of Purifying and Chemically Treating Water—June, 1923

	MONTH OF JUNE	COST PER 1000 GALLONS	SAME MONTH LAST YEAR	COST TO DATE	COST LAST YEAR TO DATE
Operating management Expenses					
Cleaning Filter Plants.....					
Labor.....					
Materials and Supplies.....					
Chlorination Treatment.....					
Chemical Treatment.....					
Repairs.....					
Depreciation—Equipment.....					
Depreciation—Building.....					
Interest on Investment.....					
Total.....					

Number of gallons purified ———.

———.

Signed

EXHIBIT C

Chapel Hill Water Works

Expenses of Pumping Water—June, 1923

	MONTH OF JUNE	COST PER 1000 GALLONS	SAME MONTH LAST YEAR	COST TO DATE	COST LAST YEAR TO DATE
Power Charges.....					
Labor.....					
Materials.....					
Repairs.....					
Depreciation.....					
Interest on Investment.....					
Total.....					

Total water pumped ——— gallons.

_____.

Signed

EXHIBIT D

List of Accounts

A typical list of accounts is shown below for such a system as described in the accompanying article. The accounts are numbered and the kinds of debits and credits for the operating expense accounts are indicated by means of these numbers. For instance, the "Operating Management Expense"—Account No. E-9—is debited with E-5 and E-6, salaries and depreciation of office equipment, respectively, and credited with E-14, E-15 and E-18, showing that this expense is prorated over the "Collecting System Expense," the "Purification and Chemical Treatment Expense" and "Distribution Expense" accounts.

(A) *Assets*

A-1. Cash
A-2. Notes Receivable
A-3. Accts.-Receivable (2)
A-4. Materials and Supplies
A-5. Plant and Equipment (2)
A-6. Construction Work-In-Progress
A-7. Reserves for Depreciation
A-8. Sinking Funds

(L) *Liabilities*

L-1. Notes Payable
L-2. Accts. Payable
L-3. Funded Dept.
L-4. Surplus

(I) *Income Accounts*

I-1. Metered Water Service Revenue
I-2. Hydrant Rentals
I-3. Flat Rate Revenue
I-4. Municipal Revenue.
I-5. Miscellaneous Revenue
I-6. Dividends Receivable
I-7. Interest Income

(E) *Expense Accounts*

E-1. Interest Expense
E-2. General Administrative Exp.
E-3. Accounting and Commercial
E-4. Bad Debts.

E-5. Pay Roll

A-1 (From time tickets)	E-9	E-11
	E-15	E-3
	E-14	E-10
	E-18	E-13
	E-8	
	E-2	

A-4. Materials-and-Supplies

A-1	E-14	E-8
	E-15	E-13
	E-18	

E-6. Depreciation

Res. for Dep. (A-7)	E-9	E-13
	E-14	E-12
	E-15	E-20
	E-18	E-2

E-7. Interest-on-Investment

(S)	E-9	E-13
	E-14	E-12
	E-15	E-20
	E-18	E-2

E-8. Repairs

A-4	E-14	E-13
E-5	E-15	E-20
	E-18	

E-9. Operating M'g'ment. Expenses

E-5	E-14
E-6	E-15
E-7	E-18

E-10. Cleaning Exp. (Filter Plant)

E-5	E-15 (1)
E-16	

E-11. Cleaning Exp. (Water Mains)

E-5	E-14
E-16	E-18

E-12. Storage Expenses

E-6	E-18
E-7	
E-8	

E-13. Pumping Expenses

E-5	E-8	E-18
E-6	A-4	
E-7		

E-14. Collection System Expenses

E-5	E-9	E-16
E-6	E-11	
E-7	A-4	
E-8		

Purification and Chemical

E-15. Treatment Expenses

E-5	E-10	
E-6	E-20	E-16
E-7	A-4	
E-8		
E-9		

E-16. Cost-of-Purified Water

E-14	E-10 (1)
E-15	E-11
	E-19

E-17. Cost of Wasted Water

E-19 (1)	E-18

E-18. Distribution Expense

E-5	E-9	E-19
E-6	E-11	
E-7	E-12	
E-8	E-13	
(1) E-17	A-4	

E-19. Cost of Distributed Water

E-16	E-17 (1)
E-18 (1)	S

E-20. Chlorine Treatment Exp.

E-6	E-15
A-1 (Commercial chlorine)	
E-7	
E-8	

Summary of Revenue and Expense

E-1	E-19	I-1	I-6
E-2	L-4	I-2	I-7
E-3		I-3	E-7
E-4		I-4	
		I-5	

(1) It will be noted that the "Cost of Distributed Water" includes "The Cost of Wasted Water," and the "Cost of Wasted Water" includes part of the "Cost of Distributed Water," making it necessary to estimate the "Cost of Wasted Water" to secure the total "Cost of Distributed Water." Any difference between this estimate and actual cost would be transferred to "Profit and Loss." The same condition exists in the "Purified Water" and the "Cost of Cleaning Filter Plant" accounts.

(2) Controlling account for subsidiary ledgers.

WATER MEASURING DEVICES[1]

By Robert L. Daugherty[2]

This paper has not been prepared for the specialist in hydraulic engineering, but rather for the benefit of the greater number who are concerned with the broader and more general aspects of the subject. It has been deemed advisable, therefore, to confine this treatment to a presentation of the different methods of water measurement in such a way as to make clear the circumstances under which each might be used and to point out the advantages, disadvantages and limitations of each device. Obviously, in covering such a broad field it will be impossible to give here sufficient detailed information about every different method as to enable one to apply it successfully. Before using any water measuring device one should make a thorough study of its manipulation in order to avoid errors; but this question is beyond the scope of this paper.

Methods of water measurement may be divided into two broad classes, direct and indirect. The direct are the obvious ones of weighing or measuring volume, and in practice can seldom be used. The commonly used methods are indirect, in that the flow of water is computed as a function of some readily measured quantity. As a rule the devices employed require formulas and coefficients, whose values may be found by experiment. Generally speaking any device, the formula for which can be determined by theory, is to be preferred to one whose formula is purely empirical. But of even greater practical importance is the determination of the coefficient to be used in the formula. Any device for which this coefficient can be computed by theory, or the theoretical value is so near the actual value that one can estimate the latter with but small error, is to be preferred to a device for which the coefficient cannot be even approximately established without calibration. And a device for which this coefficient is approximately constant in value is better than one for which it is variable.

[1] Presented before the California Section meeting, October 26, 1923.

[2] Professor of Mechanical and Hydraulic Engineering, California Institute of Technology, Pasadena, Calif.

The most generally accepted method of water measurement is doubtless the weir. Its formula in its simplest form can be derived by a theory founded upon certain assumptions that are known to be untrue. Hence it must be rectified by the introduction of an experimental coefficient. Certain persons in an attempt to express the variations of this coefficient have devised more or less complicated formulas which are largely empirical in their nature. The Bazin weir formula is one ilustration; the Francis formula for a weir with end contractions is another. However, because of the widespread use of weirs and the vast amount of experimental work that has been done upon them, they now offer us a device by which we may attain a fairly high degree of accuracy, provided certain standard proportions are adhered to in their construction and the formula and coefficient are properly chosen to fit the conditions.

If one had a free choice of the type of weir channel that could be used, the highest degree of accuracy and the simplest formula would be obtained by having the weir and the channel of approach of the same width so that there were no end contractions and with the channel so deep that the velocity of approach is inappreciable. In such a case the simple Francis formula may be used and the evidence seems to show that the coefficient 3.33 is constant, except for very small values of the head, throughout the range of head even up to values as high as 5 feet.

If the channel must be shallow and wide, it may be necessary to use a rectangular weir with end contractions, that is the weir opening is not as wide as the channel. End contractions are held to be a source of error and the correction in the formula for them is purely empirical and obviously irrational in form, since the equation would give zero flow, if the head were high enough, and a negative discharge, if the head were still higher. It is clear then that such a weir can be used only within the limits for which the formula was devised.

Third in order of choice would be a weir without end contractions and with a shallow channel so that the velocity of approach is quite appreciable. The correction for velocity is purely empirical and gives rise to various formulas. The writer favors either a modern modification of the original Francis formula or the Bazin formula to fit this case. The latter formula in particular was devised to fit the test results obtained under these conditions.

In addition to the three types of rectangular weirs there are other special forms. First is the trapezoidal weir which would replace the

rectangular weir with end contractons. Its sides slope in such a way as to offset the decrease in the width of the stream as the height of the water increases and thus gives a somewhat simple formula. But it is not necessarily any more accurate because its formula is simpler. In fact it is questionable whether it is as accurate.

For measurement of very small flows and particularly for the measurement of a flow of water which may range from very small to quite appreciable values, a triangular weir offers decided advantages. Some very excellent work on this has been done by James Barr in England. He shows that the channel width should be at least eight times the head on the weir if the flow is to be unaffected. A narrower channel increases the discharge for the same hook gage reading. On the other hand, too shallow a channel decreases the flow.

Since weirs are used not only for the measurement of cold water, but also in power plants for the measurement of hot water, the question naturally arises as to the effect of temperature. A change in temperature of the water alters its density, viscosity, surface tension, and other properties. However a series of tests made at Cornell University by F. G. Switzer and the writer showed that the effect upon the volume discharged could not be detected. This was because some of the changes in the properties tended to increase the flow and others to decrease it and these factors offset each other to such an extent that the net effect was inappreciable.

Within the last few years Clemens Herschel has proposed a new type of weir deviating materially from the standard types previously used. It appears to offer considerable promise, but more experimental work must be done before we could adopt it without calibrating each individual weir built. The advantage of the standard weir is that we may use for our weir coefficients which have been derived by calibrating other weirs of like construction and proportions.

The use of a weir of any type requires an open stream of water in which we can have a fall of a few feet or more. In many cases this is impossible. Other devices for the measurement of an open stream are floats, the current meter, the Pitot tube, and chemical methods of which there are two types.

Floats of various types were extensively used at one time and are still used in special cases to obtain the velocity of a stream. Since water in a given stream may be flowing at widely different velocities at different points in the cross section, it is necessary to

obtain a number of such velocities and multiply each velocity by the area, within which it is assumed to be the average. The summation of all such products is the total stream flow. When used by experienced observers floats are said to give a reasonably high degree of accuracy, but, as they are not very popular at the present time, no further space will here be devoted to them.

The current meter is one of the most popular devices for measuring velocity at a point in an open stream. The calibration of a large number of current meters show that for most of them the relation between meter speed and velocity of the water is a straight line. But the equation of this straight line must be found for each meter by test. It cannot be calculated. Hence one cannot use such a device without having it calibrated. The most generally used current meter in this country is of the cup type. It is rugged and reliable, but suffers from the disadvantage that it registers velocity regardless of direction. What we desire to measure is the velocity at right angles to the cross-sectional area or the component in that dircction, if the true velocity is not really perpendicular to the area. Screw or propeller types of current meters on the other hand tend to measure the component of velocity parallel to their axis of rotation. And for a reverse current in an eddy they run in the opposite direction, thus showing that the velocity is in a negative direction. The cup meter on the other hand always turns in the one direction. This causes it to read too high in a stream where there are marked irregularities and eddies in the flow.

The Pitot tube, in the opinion of the writer, is a very useful and accurate instrument in the hands of an experienced observer. Like the current meter, it measures the velocity at a point. Among its advantages are that its formula can be computed by theory and its coefficient is known to be unity. Hence no calibration is necessary. At this point, however, our attention should be directed to two factors of practical importance. One is that in a stream with a pulsating flow the readings of the tube would naturally vary in proportion to the square of the velocity and the head we should read would be due therefore to the mean of the squares of the velocities and this is greater than the square of the mean velocity, which is what we desire. Hence with pulsating flow the tube reads a little too high. The second factor is the relation of the position of the tube to the direction of the stream. If the flow were steady and if the tube faced exactly up-stream, we should have the same reading, and hence the

same coefficient of unity, whether the tube were sharp pointed, a small hole in a flat plate, or cup shaped. But if the tube is turned through a small angle we find that the sharp pointed or the cup shaped both give practically the same reading as before, while a blunt nosed tube (of which a small orifice in a flat plate would be an extreme type) gives a slightly smaller reading. This is because the former two tend to measure true velocity regardless of direction, while the blunt nosed tube tends to measure the velocity proportional to the component of pressure perpendicular to its orifice. What we desire, as a rule, is the value of $V \cos A$ where V is the true velocity and A is the angle between it and a line normal to the cross-section area of the stream. The blunt nosed tube however tends to measure $V \sqrt{\cos A}$ which is a somewhat larger value. Now, in the actual stream where the flow is more or less turbulent, we have a combination of these two factors, fluctuations in the magnitude of the velocity and variations in its direction. The effect of the two is to give a Pitot tube reading somewhat higher than that corresponding to the true value of $V' \cos A$, where V' is the mean velocity desired. Hence we must introduce a coefficient whose value seems to be very close to 0.98. But it should be noted that the necessity for the coefficient is due to the turbulence of the flow rather than to any inherent defect in the theory or in the instrument itself, and it is largely necessary because we desire the component of the velocity rather than the actual velocity itself. If we desired the actual velocity regardless of direction, we should use either a sharp pointed or a cup shaped point, but the coefficient to give us the axial component of the velocity would be somewhat less than 0.98 for such tubes.[3]

Even in cases where the degree of turbulence is unknown, the amount of error in the use of the Pitot tube is largely measured by the error in judgement involved in choosing a coefficient whose value may range from 0.98 to 1.00.

In the case of an open stream, it is convenient to have some means by which the column of water in the Pitot tube may be drawn up by a partial vacuum to a more convenient location for reading. A second tube should then have a column drawn up in it by the same

[3] A most excellent paper on this subject by Lewis F. Moody, based on investigations by Moody and F. H. Rogers conducted at the Rensselaer Polytechnic Institute, may be found in the Proceedings of the Engineers Society of Western Pennsylvania, vol. 30, no. 4.

vacuum and proportional to the water surface of the stream. The difference between the two gage heights is then the Pitot tube reading.

While the Pitot tube may be used in a flowing stream for fairly low velocities, it may also be used with equal satisfaction for measuring high velocities in jets of water, even as great as two or three hundred per second. The only difference is one of mechanical construction and the type of device for recording the pressure.

It would be well to point out at this time that the Pitot tube may be used also in closed pipes under pressure. But in this case a reading of the pressure in the pipe must be substracted from the Pitot tube reading. In the past there has been much difficulty encountered because of the failure to record this pressure accurately. The best way is to have a piezometer connection in the wall of the pipe and not to attempt to use a static pressure orifice as part of the tube itself. Any pipe projecting within a flowing stream will not give a true measure of the pressure, unless some special construction is used on the end of such a pipe so as to cause the stream lines past the orifice to be the same as if the orifice were in the pipe wall.

In using the Pitot tube in a pipe it is desirable to make two traverses across two diameters at right axes to each other, as the velocity distribution may not be uniform. For subsequent use the work may be shortened by placing the tube at a point where the velocity has been found to be the same as the average velocity or else the tube may be placed in the center of the pipe, where the velocity is a maximum, and the average velocity for the section determined by multiplying the observed value by the proper factor.

Of the chemical methods there are two kinds that differ fundamentally. In one, some color is added to the water and the time that is required for that color to traverse a certain length of path is observed. Obviously this can be applied only to some artificial conduit of uniform cross-section, or a series of such conduits, because velocity must be multiplied by area in order to obtain the rate of discharge. In the case of a natural stream it could be used only if the bed of the stream were fairly uniform for a sufficient distance.

The Ontario Power Company at Niagara Falls at one time used this color method for determining the flow through their penstocks. They constructed a mechanically operated device by which they could discharge about a pound of potassium permanganate crystals into the upper end of the penstock. Desiring to check up the accuracy of this method I tried some potassium permanganate in a

6-foot pipe line 1711 feet long with the water at the lower end flowing over a weir. To my surprise I could see no trace of any color at the lower end. Afterwards I learned that potassium permanganate would be oxidized and rendered colorless, if there were any inorganic matter in the water. Apparently the conditions were different at Niagara Falls.

Later I tried out this chemical method in another place and used a number of different kinds of chemicals. I found that the green colors were best, blues were next, and the reds, purples, and browns were least satisfactory. The difficulty with this last set was that, however vivid the colors might be when made up, they became so pale when considerably diluted that it was hard to tell when they appeared in the water, especially with changing light conditions, as a shadow drifting over the water gave the same effect as these colors. But with the greens especially, there was no difficulty. One could detect the first traces without any question. Of the greens I found that aniline green and fluorescein were both good, but I doubt whether it would be well to use them in water that was to be employed for drinking purposes. I am told that there is a light green color given by a chemical known as S. F. Yellow, which is non-injurious. Indigo disulfonic acid is likewise said to be non-injurious and to give a blue color.

Now as to the accuracy of this method. I desired to see what results I could accomplish with a minimum amount of effort. I took an assistant, therefore, a couple of stop-watches, and the chemicals to a plant where water from a stream entered the intake to a pipe line about 550 feet long, then passed through a turbine, and appeared in the tail race. It would be desirable to have a longer distance than this possibly in order to lengthen the time measured and thus increase the accuracy. Even in this short distance the pipe line was made up of varying sizes ranging from 31 inches in diameter to 72 inches. Thus, I did not consider the situation particularly favorable. Instead of an arrangement to inject the chemical direct into the pipe the color was simply dissolved in about a quart of water and dumped quickly into the intake box. It took 30 seconds for the color to disappear from the time it was poured in. A trace of color would appear in the tail race in 80 seconds, become of maximum intensity, and then fade out in 110 seconds. I decided that the proper time interval to allow was 80 seconds, as that was the time from the injection of the color to the appearance of the first trace and likewise the time that

elapsed between the disappearance of the last of the color at intake and the disappearance of the last in the tail race. From a rating of the water turbine used, from a current meter investigation, from observations of the same flow over the crest of a dam considered as a special weir, and from computations made on the losses of head in the pipe line, it had been decided that the rate of discharge was very close to 45 cubic feet per second. When the computation of the flow from this 80-second interval was completed the result was exactly 45 cubic feet per second. I can recommend this method therefore as being quite reliable and very simple to carry out. A variation of this is to use a salt solution instead of a color and to time its appearance at the lower end of the channel by noting the change in conductivity of the water. However, this is more trouble and does not possess any advantage, except in situations where the color could not be observed, as in a closed pipe for example.

The other chemical method, which has many advantages, the chief of which is that no definite length of uniform channel is required, is to run into the stream a small quantity of a strong salt solution of a known concentration and at a known rate. Samples of the mixture are then taken downstream and analyzed to determine the amount of dilution. Knowing the salt concentration before and after and the rate at which the solution was added, it is easy to compute the flow. This method is simple and cheap and is believed to permit of a high degree of accuracy.

The methods of water measurement previously mentioned are possible only in open stream, except for the Pitot tube and the chemical methods, which may be used with either open streams or closed conduits. We shall now turn to those devices which can be used only in the case of water flowing in closed pipes.

Chief among these is the Venturi meter. It is simple, reliable and accurate. It is only necessary to insure that the connecting piping from the meter to the recording device is neither stopped up with sediment nor partially filled with air. The latter can usually be avoided altogether by properly arranging the piping in the first place. The formula for the Venturi meter can be derived by theory and is so nearly correct that it is only necessary to introduce a coefficient whose value is from 0.980 to 0.985 according to the condition of the meter. While this coefficient is not strictly speaking a constant, its variation is neglible within the usual range of operation.

The usual proportions for a Venturi meter are that the ratio of the throat diameter to the pipe diameter are 1 to 2 or 1 to 3. The smaller the throat diameter in proportion to the pipe, the greater the reading obtained and therefore the more accurate and the more sensitive the instrument becomes. But the loss of head in friction also becomes more pronounced, so that we strive to compromise on these two factors.

The Venturi meter, if installed in a pipe line when the latter is constructed, costs but little and seems nearly ideal for the purpose of giving us the information desired concerning the flow of water through the pipe. Its only disadvantage appears to be that it does add some frictional resistance to the flow of water which may or may not be of much importance. In a specific case of water flowing through a 6-foot pipe line with a velocity of 7 feet per second the insertion of a Venturi meter caused a loss of head of 7.40 feet, which amounted to a friction loss of 166.5 h.p. In this case the power of the turbine supplied by the pipe line was 10,000 h.p. and this friction loss is only a small percentage of the total. This power, however, has a definite money value, whatever its percentage may be. If a Venturi meter be inserted, therefore, in any line from a pumping plant, it will add slightly to the cost of pumping. The problem then becomes one of deciding whether the information obtained is worth the cost. In a gravity line this element drops out, though the meter then would decrease very slightly the capacity of the pipe.

It is somewhat difficult and expensive to install a Venturi meter in a line already constructed and in such cases the orifice meter may be of value, especially for temporary use. This consists of an orifice in a thin plate which may be inserted between the flanges of two adjoining lengths of pipe. If forms a sort of crude Venturi meter, as one measures the drop in pressure due to the increased velocity through the orifice. The difficulty about applying it is that one has to know just where the two pressure connections should be made upstream and downstream and one must use an experimentally determined coefficient. In another type the pressure difference is measured by small orifices in the two sides of the orifice plate itself, thus having some relation to the Pitot tube in principle. This type has the merit that it is entirely self contained and requires no connections made elsewhere. An objection to the permanent use of the orifice meter is the loss of head occasioned by it. For example, in comparison with the Venturi meter previously mentioned, where the

loss of head was 7.40 feet, the orifice meter, under similar circumstances and with the orifice diameter the same as the meter throat diameter, would cause a loss of head of 142 feet. Of course, this means that we should modify the arrangement so that the velocity in the pipe is less or the ratio of orifice diameter to pipe diameter is greater, although at the expense of sensitiveness of reading. Still another method of water measurement is to use an orifice or a nozzle on the end of a pipe where the water may be freely discharged into the air. We have two cases here, also, one where a high velocity jet is discharged under a high pressure and the other where a low velocity jet of considerable size discharges under a low pressure. In both cases formulas and coefficients are known within a reasonable degree of accuracy. There are also two methods of taking the required observation. The usual one is to measure the pressure in the pipe above the orifice. The other is to use a Pitot tube in the center of the jet only and to obtain the discharge from this one reading by the aid of previous calibrations.

It has long been known that when the flow of water through a pipe is stopped within a short interval of time, not necessarily instantaneously, there is a marked rise in pressure, an exaggerated case of which, when the time interval is very small, is known as water hammer. Of course this pressure is only momentary and soon diminishes to normal value. Recently N. R. Gibson has made use of this principle to compute the initial velocity of the water from a measurement of the pressure-time diagram recorded by a special apparatus, as the flow is being stopped. This method appears to yield very accurate results and requires nothing but this photographic recording apparatus connected to the pipe line by a $\frac{1}{4}$ inch tap.

So far all these water measuring devices have been considered from the standpoint of their instantaneous readings, as they would be used by an observer during a test. The current meter, the color and salt solution methods, and the Gibson pressure wave method do not appear to be adapted to any other circumstances. But, in the case of a weir, for example, an observer may make an instantaneous observation with the hook-gage or a recording float mechanism may give us a continuous record of the stream flow. The same is true of the Venturi meter, the orifice and the nozzle. In the case of the Pitot tube, it could be set at a predetermined location and a continuous record made of the pressures obtained. It does not appear to the writer, however, to be especially suitable for that. It might be all right in

clear, clean water, but under ordinary circumstances the lodging of a little sediment or stringy material on its point seriously affects its reading. It seems to be quite satisfactory in the hands of an observer, but of doubtful value as a device to be employed with a continuous recording mechanism.

While there are many other devices for the measurement of water aside from those discussed in this paper, it is believed that these are the ones of most interest. It is apparent that the choice of the device to be used is determined very largely by the circumstances in each case.

OPERATION RECORDS FOR SMALL WATERWORKS[1]

By Earle L. Waterman[2]

During the past four years the writer has had occasion for one purpose or another to inquire for the operating records at a number of small waterworks plants in Iowa. Generally the result of these inquiries has been to find that there are few such records. The value of operating records in large waterworks plants is accepted without question and the forms in which such records are kept are becoming more standardized each year. Is there any factor which depends on the size of a water works plant which determines whether or not operating records are worth keeping? If we can agree that such records are worth while for the small, as well as the large, waterworks then it seems to the writer that such a group of waterworks men as are gathered here for the meeting of the Iowa Section of the Association should take the initiative in trying to obtain more and better operation records at the small water plants. It is the purpose of this paper to point out the value of operation records to discuss the existing situation, to suggest methods of improvement and, if possible, to start a discussion on a subject which appears to deserve the attention of an association of waterworks men.

It is rather difficult to define the term small waterworks. In a paper on "Modern Pumps for Small Waterworks," which was published in the *Journal of the New England Waterworks Association* in March, 1920, Mr. C. W. Fulton includes under Small Waterworks those plants which have a daily capacity of 3,000,000 gallons or less. Such a classification may perhaps serve the purpose of this discussion, although the writer feels that in the Iowa plants whose capacity is 500,000 gallons or more per day some effort is generally made to keep records of operation. While in most cases these records can be improved—particularly in those plants which under our classification may be called small waterworks—it is in the smaller plants,

[1]Presented before the Iowa Section meeting, October 24, 1923.

[2]Associate Professor of Sanitary Engineering, University of Iowa, Iowa City, Ia.

whose capacity is less than 500,000 gallons per day, that the greatest improvement can be made. Definite data concerning the number of these plants are not available, but from such information as could be obtained the writer estimates that out of 500 plants in Iowa 490 would be classed as small waterworks and, of this number, 464 have a capacity of less than 500,000 gallons per day.

The records which ought to be kept at a waterworks plant should show all facts relating to the operation of the plant. In a broad sense the keeping of such records may be called bookkeeping or accounting. However, properly kept records will not only show costs of operation, but will also show pertinent facts in regard to the quality of the product and point to reasons for variations in quality. A successful waterworks plant is one which supplies water which is satisfactory from every standpoint, to its customers, and also gives good service at ~~at~~ minimum cost. The facts in regard to the operation of such a plant should be kept in permanent form so that they may be always available. We profit by experience—the operating records should be a complete record of experience obtained in operating a waterworks plant. When it is too late we often find that the memory of the plant superintendent is not as trustworthy as a written record.

The operating records should include an inventory of all plant equipment, a record of the amount of water furnished to the distribution system each day, amount of power used per day, pressure maintained, occurrence of fires, labor costs, plans of the distribution system, all changes in the distribution system, installation and removal of meters, meter testing, quantities of chemicals used for treatment, data concerning treatment, and the results of the examination of all samples of water which are analyzed to determine the quality. It is probable that other items should be included. This is not a complete list by any means and is offered only for the purpose of suggesting what the writer has in mind when he uses the term operating records. It will be noted that, aside from labor costs, which are a factor of operating costs, the financial items are not included. The reason for this omission is that such records do not always come under the province of the superintendent of waterworks. It is not our purpose to discuss the important matter of the determination of water sales rates.

The operating records should be of the greatest value to the plant operator. Such records ought to enable him to operate the

waterworks plant in the most efficient manner. The efficiency of the plant units as well as the efficiency of the plant as a whole can be determined. If the plant is not operated continuously, a study of the operating records should show at what times and for how long a period the plant can be most economically run. It should show him the variations in quantity of water available at the source of supply and the variation in ordinary demand, together with the effect of fire demand. The record would show the effect of the seasons both on the quantity and quality of water and on the plant and distribution system. Some one will say that the old operator knows these things. In a general way this is true, but such information cannot be as reliable as the written record, and the new man coming on to the job does not inherit his predecessor's memory! Properly kept operating records should be invaluable to the man who makes them.

The making out of reports to the State Board of Health and to the State Public Utilities Commission will be very much easier for the man who keeps a daily record of his plant operation. These state supervisory authorities are not unjust in their requests for information. The object of such supervision is to protect the health and the pocket book of the citizens of the state. Speaking only from the standpoint of the water utilities we must admit that the primary function of such public utilities is first to furnish a safe and satisfactory water, and, second, to supply such water to the consumer at a reasonable cost. Then the question arises as to who is to determine whether or not these requirements are being fulfilled? The consumer knows whether or not the water is satisfactory, but he is a poor judge of its safety and has very little knowledge on which to base an opinion as to the cost. Safety and cost are matters to be determined by specialists and for the small water works the services of qualified experts in such matters is not feasible from an economic standpoint. When such advisory service is furnished by the state, plant operators should realize its value and by hearty coöperation obtain maximum benefits from it. Operating records make such coöperation possible and not a burden.

Most small towns and cities have the laudable ambition to grow and history shows that a majority of them do increase in size. Growth means enlargement, extension, and improvement of the waterworks plant. When these matters come up for consideration the first inquiry made, by the engineer who is to make the plans,

is for the past records of plant operation. On the basis of such records he is able to forecast more accurately the probable future demands and plan for a plant that will furnish a safe, satisfactory and economical water supply. The degree of success which he attains will be largely measured by the data which he finds available. Operating records are valuable in planning improvements to the waterworks plant.

At a majority of the waterworks plants in Iowa where some form of purification process is used operating records are being kept. The Chief of the Water Laboratory of the State Board of Health has been making a very commendable effort during the past two years to encourage the keeping of such records. If the plant operator keeps only a duplicate of the weekly reports which are required by the State Board of Health he will at least have a fair start on operating records.

Perhaps the most serious obstacles in the way of getting operating records at small waterworks are, first, lack of proper equipment and record forms, and second, the fact that in many cases the operation of the waterworks plant is only a part of the duties of the man who is city marshal and superintendent of streets. Probably not more than one-fourth of his time is devoted to the waterworks. With so many things to claim his attention it is not surprising that he does not keep records at the waterworks.

If such records are to be obtained, it is essential that simple forms be planned and further that some equipment for measuring pressures and recording the amount of water furnished by the plant be installed. A recording pressure gage will be very helpful to the operator. Venturi meters or master flow meters may be used to determine the daily flow. If it is not possible to install a meter, a stroke counter on the pumps at pumping plants may be used. Where the plant is not run continuously the time of starting and stopping should be recorded. In the smaller plants the furnishing of a diary or log in which daily notes can be made may serve to encourage the operator to make some records.

Remarkable progress in waterworks operation has been made during the last twenty-five years. Much of this advance in knowledge has been due to the work of the American Waterworks Association and the benefits have been reaped by men whose time is entirely devoted to waterworks. Should not this work be extended to help the operators of smaller plants? There are hundreds of

them in Iowa. A committee on operation records for small waterworks would find a large field in which to work and, in the writer's opinion, a field in which assistance would be greatly appreciated. Work of this kind ought to result in interesting small waterworks operators in the work of this Association. Up to this time these men have not been interested. Has not the time come when some constructive effort should be made to obtain their interest and coöperation?

SENSITIVE DETECTION OF SUSPENDED MATTER AND A PROPOSED STANDARD OF CLARITY IN FILTERED WATER

By John R. Baylis[1]

A few years ago the author attended a performance in one of the local theaters in which one of our famous "bathing beauties" gave an exhibition of her diving stunts. The tank used had a glass side in order that she might be observed while under the water. Greatly to his surprise and to the disappointment of the "bathing beauty," she could scarcely be detected while under the water, unless very close to the glass side. Water that had passed the filter plant and was recorded as having zero turbidity fell far short of its classification. Not long afterwards another shock was received when informed by the manager of one of the swimming pools that it was necessary for them to construct and maintain a filter plant to clarify the city water for bathing purposes. Many industries were still operating their old private filters that were constructed before the Montebello Filters were put in operation. This gave added proof that the clarity of our water was not meeting the demands of the consumer in many instances. When they complained of cloudy water we would point with pride to the column in our daily report showing zero turbidity practically all the time. The consumer usually went away with the feeling that it might look all right on paper, but the water was not satisfactory. Zero turbidity meant nothing to him when he could not see clearly the bottom of his white bathtub. In the course of time we began to feel that possibly our bottle sample of water about 4 inches in diameter was not giving an accurate means of detecting suspended matter.

A submarine light was installed in the bottom of one of the clear water reservoirs at the Montebello Filters in 1918, where it would be under about 8 feet of water. When the light was first turned on we were undecided whether it should be left in the place installed

[1] Principal Sanitary Chemist, Baltimore Water Department, Baltimore, Md.

or hid in some secluded spot where only the superintendent and the chemist might observe the filtered water. This was the beginning of a great improvement in the clarity of Baltimore's water, which with the use of other sensitive devices has made it one of the clearest filtered waters supplied any city. It was found that no one device entirely solved the problem of detecting suspended matter. It may be extremely fine particles caused from imperfect coagulation, or fairly large size coagulated particles passing the filter beds, or both. If it is insufficient coagulation the chemicals should be changed to the proper amounts, and if it is suspended matter passing the filter beds the ones passing such matter should receive attention. Armstrong[2] has shown that loss-of-head cannot be used as a criterion for washing filters, especially in the winter months. With good coagulation the proper operation of filters is largely the prevention of the passage of floc. A light about 8 feet under the water with 6 or 8 feet of water around it detects turbidity, but does not tell the amount or cause. No sampling or observation device on the market offered the degree of sensitiveness desired. Consequently experiments were started in 1918 to perfect a device for installation on each filter that would sensitively detect the floc passing. After several unsuccessful efforts a device was finally perfected. A description of it has already been published.[3]

The use of some such device as this cannot be too strongly commended for the proper operation of rapid sand filters. It has met our greatest expectations in detecting floc passing the filter beds. For detecting fine colloidal particles due to poor coagulation the light under the water gives a fairly good indication, but another device is used in the laboratory for its estimation.

PRACTICALLY NO EFFORT HAS BEEN MADE TO DETERMINE TURBIDITY OF FILTERED WATER

Most of the early efforts to perfect devices for examining filtered water have been to make them show clear water. Some of the older operators possibly did not want sensitive detection of suspended matter. Had they been privileged to select devices of various degrees of sensitiveness they would have almost invariably selected

[2] Armstrong, Jas. W.: Loss of head as a criterion for washing filters. Engineering News-Record, vol. 87, December 29, 1921.

[3] Baylis, John R.: Sensitive detection of suspended matter. Public Works, January 7, 1922.

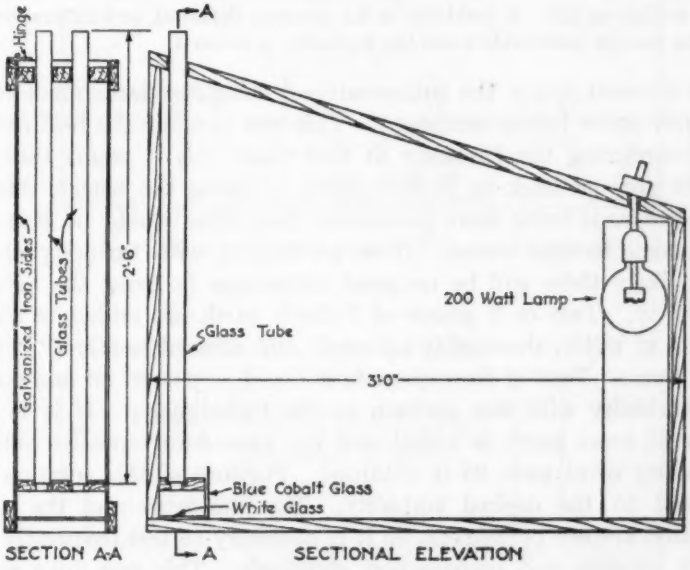
the least sensitive. To have offered turbidimeters as herein described years ago would have met with about the same reception as did Edison's device for hastening roll-calls in Congress. Something to make the water look clear when it was not would have had a ready sale in many filter plants a few years ago. It is a fact that filter operators have shown very little interest in the degree of clarity of their filter effluents as long as the turbidity is not noticeable in an ordinary half-pint glass of water.

A little turbidity may have no great sanitary significance, and a filter operator may be justified in supplying water with a turbidity of 0.5 p.p. m. or more in some instances, but he should have some means of telling just what it is. If we cannot tell whether water has a turbidity of 1 or 0.1, how are we going to ascertain the proper amount of chemicals to use and when to wash filters? We are very careful to determine that the raw water turbidity is 35 and not 34 or 36, yet we are making very little effort to tell if the filtered water is 0.5 or 0.9. At the point where greatest accuracy is needed there is the least. We prefer to look at a bottle of water that appears to be fairly clear and call it zero turbidity without making more accurate tests.

Realizing that such "rule of thumb" methods must soon disappear in water purification, the author has devoted considerable time to the perfection of devices other than the ones mentioned for laboratory uses. When the observation light that is under about 8 feet of water shows a slight cloudiness, there should be some means of determining the turbidity other than a guess. When a slight amount of floc is observed in the floc detectors on the operating tables, there should be some means of telling whether it is a floc turbidity of 0.02 or whether it is 0.10. For experimental work turbidity differences become very important. *Most of the experimental work on chemical treatment of water for clarification loses much of its value because accurate turbidity determinations have not been made on the water after filtration. It is no wonder workers differ so widely in their results when working with water of approximately the same character. Until there is greater accuracy and more uniform methods of procedure progress is going to be slow.*

NEW TURBIDIMETERS

Prior to 1923 the best method that could be found for making turbidity comparisons was to compare in 75 cm. tubes similar to the one used with the Jackson candle turbidimeter, using dilutions of the raw water for standards. This gave fairly good results, but the color interfered somewhat with its accuracy and it was necessary to have daylight for comparisons. In the early part of 1923



TURBIDIMETER FOR SENSITIVE DETECTION OF SUSPENDED MATTER

FIG. 1

an accurate and sensitive turbidimeter was perfected that not only tells turbidities as low as 0.1, but is not affected by colors below 5. Colors between 5 and 15 interfere very little. Figure 1 shows a plan of the turbidimeter.

Two glass tubes the same size and length of the 75 cm. tubes used with the Jackson turbidimeter are used for comparisons. One for the sample and the other for the solution of known turbidity. They should be as near the same clearness of glass as is possible. A box as shown in the plan is used for covering the light and holding the tubes and glass plates. The box shown was the cheapest possible to construct. So valuable an instrument should

have a neater appearance, but this does not affect its accuracy. The purpose is to get a very bright light from the side on the particles in suspension so as to illuminate them, and a perfectly blue light underneath the tubes. It is desirable to cut out as much of the white light rays as is possible underneath the tubes. The best plan possible shows a white plate underneath and a blue so-called cobalt glass on the side. This will cause all the light to be blue. With clear water containing no matter in suspension the bottom shows blue, but when there is suspended matter the white light reflected from the particles in suspension cuts out some of the blue rays. Most of the blue is cut out with a turbidity of 1, but turbidity differences may be detected when it is as high as 2.0. A turbidity of 0.1 is easily detected, and differences of 0.1 are readily noticeable when the turbidity is below 1.

In a recent article the author advised using standards made from the raw water before treatment. This was possibly the best means of determining the turbidity at that time, but it seems that we might now go back to Fuller's earth as being the better, due to the standards being more permanent than they would be if made with some natural waters. If we are dealing with turbidity alone, it is likely there will be no great advantage in using the natural turbidity. Two or 3 grams of Fuller's earth are added to about 1 liter of water, thoroughly agitated, and allowed to stand twenty-four hours. Part of the supernatant liquid is poured off and tested for turbidity with the Jackson candle turbidimeter. If it is less than 25 more earth is added and the procedure repeated until a turbidity of at least 25 is obtained. Portions of this solution are diluted to the desired turbidity. The standards and the stock solution are not permanent, so it is necessary to test frequently the stock solution and prepare new standards. This was done every week at first, but the standards change very little in two or three weeks.

This device gives a measure of the total suspended matter, which may be partly colloidal and partly floc passing the filters. It is desirable that a determination of each be made. With turbidities below 1 the floc may be of much greater importance than the colloidal matter. The colloidal matter will not settle out in the distribution mains, but will remain evenly dispersed in the solution. If not readily noticeable it will cause very few complaints. The floc is quite different, and water should be as free of it as possible. If very small quantities are present, it will settle in the pipes when the velocity is slow and may gradually accumulate to considerable amounts in places. An increase in the flow picks it up, and may

cause the water to become very turbid for a short while in these localities. Possibly all are familiar with the cloudy water in the

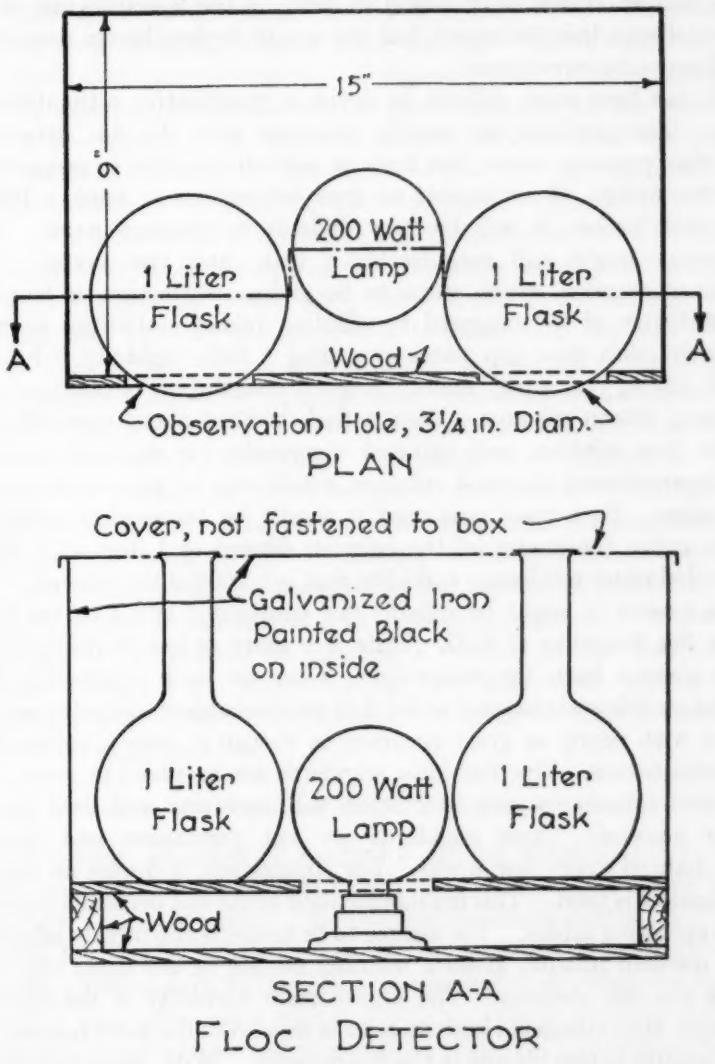


FIG. 2

vicinity of a fire or broken main. Corrosion of service pipes in many supplies greatly aids in forming these "pockets" of muddy water and may be the sole cause in some supplies. There are many in-

stances, however, where the cause is floc passing the filter beds. *No rapid sand filter plant filtering coagulated water is entirely free from floc passing the beds all or most of the time.* A few operators may wish to challenge this statement, but the use of devices herein described will prove its correctness.

It has been most difficult to devise a quantitative estimation of floc. The particles are readily observed with the floc detectors on the operating tables, but they do not tell quantity in proportion to the water. If we depend on such estimations as none, a little, or considerable, it will be very difficult to compare work. One observer might call considerable a little and vice versa. The method adopted, which seems to be giving satisfaction, is to take a turbidity of 20, prepared by diluting higher turbidities to this amount with clear tap water or adding a little turbidity if below, and adding 1.5 g.p.g. alum. A good coagulation is obtained by stirring fifteen minutes. Then a flask is filled about one-half full with this solution and agitated vigorously for one-half minute. This constitutes the stock solution, which may be kept for a month or more. Each time it is used it should be thoroughly agitated. One cubic centimeter of the solution diluted to 1 liter with clear distilled water will form a turbidity that is 1/1000 of the original. To give a name it might be called "floc turbidity," and 1 cc. per liter is a floc turbidity of 0.02. This is a more or less arbitrary scale, but gives a basis for comparison. Once we have determined the point on this scale beyond which it is not desirable to exceed it can be used with nearly as great accuracy as though it were a volumetric determination. Floc turbidity standards are prepared to cover the desired ranges, varying 0.02 below 0.10 turbidity and 0.05 above that amount. These standards are not permanent and should be changed every few weeks. For comparison, a device as shown in figure 2 is used. This is a modification of the floc detectors used on the operating tables. The sample to be tested is thoroughly agitated for one-half minute, given a whirling motion in the flask, and put into the floc detector. The approximate turbidity is determined by eye, then compared with standards treated in the same manner as the sample before placing in the floc detector. With one or two trials the turbidity may be determined accurately.

LABORATORY PROCEDURE FOR DETERMINING SUSPENDED MATTER IN FILTERED WATER

Daily tests are now made in the laboratory of the Montebello Filters on a composite filtered water sample. This is a mixture of samples taken every two hours. Frequently other tests are made to aid in adjusting chemicals. Three tests are made on this sample; one in the laboratory turbidimeter to determine the total turbidity, one in the floc detector to determine the floc turbidity, and another in the laboratory turbidimeter to determine the colloidal turbidity. One of the glass tubes of the laboratory turbidimeter shown in figure 1 is filled with water from the composite sample and allowed to stand at least five minutes for the air bubbles to rise to the surface. An approximate turbidity determination is made with the eye. The other tube is filled with a standard, the preparation of which has been described, allowed to stand at least 5 minutes, and a comparison made. One or two comparisons are usually all that are necessary for an accurate determination. The results are recorded to the nearest 0.1 turbidity if below 1, and to the nearest 0.2 if above. Turbidities above 2 may be diluted with distilled water for comparison. This gives the total turbidity. The floc turbidity is determined as previously described, and recorded to the nearest 0.02 turbidity if below 0.10, and to the nearest 0.05 if above this amount. Colloidal turbidity is determined by filtering a portion of the composite sample through filter paper that has been thoroughly washed by filtering at least 2 liters of clear water, and using the same procedure as with the total turbidity.

A PROPOSED STANDARD OF CLARITY FOR FILTERED WATER

The present standard of clarity for filtered water, if judged by filter plant records, is a turbidity of zero. The author does not offer one "quite so rigid." To propose standards without a mass of evidence to substantiate the reasons may be treading on dangerous ground. Reliance in this case has been placed on what we have found to give satisfaction with our water. Due to overloaded and other conditions we have not produced an effluent at all times entirely satisfactory from the standpoint of clarity. This has enabled us to get a fairly good idea of the limits beyond which we should not exceed.

The colloidal turbidity should not at any time exceed 0.5, and the composite sample should not exceed 0.2. The floc turbidity for the combined effluent should not at any time exceed 0.04, and the composite sample should not exceed 0.01.

This may be setting up a very rigid standard for filtered water, as very few plants are producing such an effluent. The almost universal use of chlorine has, in the opinion of many, obviated the necessity of operating filters at their greatest efficiency. The author does not concur in this opinion. It has been his experience that the water consumers are willing to pay for the best possible. The record of failures to ratify bond issues for improvement to water supplies are few where the issues are for an improvement in the quality of the water. The value of satisfaction is recognized by nearly every one, and the sooner our water works officials realize, with our present standard of living, that quality within certain bounds is preferable to economy the sooner will the desired progress be made. Failure of our officials to keep abreast of new developments is now doing more to retard progress than protests of increased costs from the consumers.

A STUDY OF THE EFFICIENCY OF THE IMPROVED WATER PURIFICATION PLANT AT WILMINGTON, N. C.[1]

By George D. Norcom[2]

During the past few years there has been a great deal of activity by the various cities of North Carolina in building water purification plants and improving the plants already existing. No doubt this movement has met with opposition in some quarters, since there are always those who are satisfied with conditions be they ever so unsatisfactory. It occurs to the writer that, if some of the improved plants could show in simple terms the benefits derived from the improvements, the opposition would be effectively silenced. It is the object of this paper to describe briefly the changes which have been made in the Wilmington plant, to compare the efficiency of the new plant with the old and to discuss the relative costs of operation.

Since 1882 the raw water for Wilmington has been taken from the Northeast branch Cape Fear River, a highly colored and rather polluted stream. At first the water was used without treatment, but since 1906 it has been subjected to rapid sand filtration and of late to chlorination. Before alterations were made last year the plant consisted of the following units: Three sedimentation basins with a combined capacity of 1.53 million gallons, so designed to as give a high velocity of passage (0.86 feet per minute), 12 filters of 0.5 million gallon each per twenty-four hours, chlorine apparatus, clear well, standpipe and storage reservoir. The purified water was pumped directly to the mains, the plant being operated twenty-four hours per day. Alum and lime solutions were fed through orifice boxes directly to the raw water pump suction, there being no mixing chamber. Chlorine was applied to the clear well by means of a duplicate installation of Wallace and Tiernan chlorinators. The

[1] Presented before the North Carolina Section meeting, November 14, 1923.

[2] Sanitary Engineer, County Board of Health, Wilmington, N. C.

filter sand was of three different types ranging in effective size from 0.36 to 0.62 mm. Air and water wash was used.

The principal objections to the old system were as follows: The raw water was highly colored and at times turbid, so that it required constant supervision at all times. In spite of this, unsightly water gained access to the mains occasionally. The water was polluted with fresh sewage from the city, since it was possible for sewage to reach the intake within thirty minutes after its discharge into the river. Judged from its B. coli content the water was too highly polluted for a safe load on the purification plant. The water was subject to pollution from sea water so that at times it became absolutely unpalatable and caused considerable damage to boiler tubes and hot water systems. The filter plant was of peculiar design representing three different periods of building. There was no mixing chamber. The pipe connections between the basins were small and in some cases inadequate. The basins were designed to give a high velocity of flow. Eight of the 12 filters were provided with Earl controllers which were not satisfactory. The use of air and water wash resulted in clogging of the underdrains and imperfect washing. The sand in some of the units was too coarse.

During the past year a new raw water supply has been secured and the plant has been completely overhauled. Two miles of twenty-four-inch C. I. pipe including a 600-foot river crossing were required to secure water from the Northwest Branch of the Cape Fear River at a point on the river nearly 5 miles above Wilmington. The new supply is a turbid stream having a mineral content fully as low as the Northeast Branch and practically free from sewage pollution. The only town of any size on the watershed is Fayetteville about 80 miles above the intake. Moreover, the chance of sea water contamination of the new supply is remote. A new low lift pumping station is located on the Northwest Branch where two electrically operated centrifugal pumps of 4 million gallons per day capacity each deliver water to the sedimentation basins. A recording Venturi meter is placed in the filter house.

A mixing chamber with over and under baffles has been provided which is designed to give twenty minutes retention at a velocity of 0.8 feet per second when operating at a rate of 6 million gallons daily. The effluent from the mixing chamber is discharged through a diffusing wall into the main sedimentation basin which has a capacity of 800,000 gallons. By allowing the water to enter at the side of this

basin and flow across, the velocity has been reduced to 0.35 feet per minute without altering the retention period of 3 hours. The two small basins which are of 360,000 gallons capacity each, have not been changed, although the piping between the basins has been arranged to allow flexibility of operation.

The old solution feed apparatus for chemicals has been replaced by three Roberts dry feeders. Two of the machines feed alum and lime to the first basin, while the third is used for adding lime to the basin effluent to restore alkalinity.

All filters have been equipped with Simplex controllers and resanded with a local sand of effective size 0.49 mm. and uniformity coefficient of 1.33. This sand is not as fine as had been specified, but it appears to be giving satisfactory results. High velocity wash has been substituted for air and water, wash water being supplied from an elevated tank of 50,000 gallon capacity.

This is a brief statement of the improvements made. A full description has been written by C. W. Smedberg, Sanitary Engineer, and will be found in Public Works for September, 1923. The engineers on this work were the Carolina Engineering Company of Wilmington, N. C., and the contractors were Tucker and Laxton of Charlotte, N. C.

The new supply was put into service on April 20, 1923. It had been studied by Prof. E. B. Phelps, Mr. Geo. F. Catlett and the writer, and it had been unanimously recommended as superior to the old supply both as regards quality and ease of treatment. The results of numerous analyses indicate that, chemically, the waters are practically identical. Physically they are entirely opposite, the one being highly colored with little turbidity and the other highly turbid with little color. In this difference lay the opportunity for increased economy, laboratory experiments indicating that the turbid water would require only about one-half as much alum as the colored. While the advantage of the mixing chamber and low velocity of basin flow was scarcely apparent on the colored water, it was very marked on the turbid water. With the colored water coagulation appears to be instantaneous and a good floc appears at once if optimum conditions are realized, but with the turbid water containing colloidal clay the benefit of the stirring action is apparent to the eye, it being possible to follow the progressive formation of the floc and subsequent clarification effected as the water passes through the mixing chamber. An important point in this con-

nection is that the optimum for good coagulation is pH 4.4 with the colored water and pH 5.5 with the turbid water, while the pH range for good coagulation is much narrower with the former than with the latter. When the coagulated water passes through the diffusing wall most of the floc settles quickly as can be demonstrated when the basin is drained for cleaning. By utilizing various basin combinations it is possible to secure retention periods from two and four-fifths hours to twelve hours at the rate of 3 million gallons daily. The most advantageous retention period for the warm months seems to be about eight hours.

The dry feeders for chemicals have proved greatly superior to the old solution feed. Stratification of alum solutions and clogging of lime orifices have been obviated. It is now possible to maintain a uniform feed and to regulate the dose according to the flow as indicated by the Venturi meter.

The high velocity wash has already saved us a considerable amount of wash water and it is believed that it will overcome many of the difficulties formerly experienced from clogged underdrains and uneven application of wash water. The Simplex controllers have given complete satisfaction. The removal of bacteria by the filters equipped with the new sand has been uniformly efficient.

In table 1 will be found the average results for total bacteria and B. coli for five months of 1923, the corresponding five months of 1922 and for the three year period, 1920–1922. In table 2 the corresponding percentage removals are shown. It will be seen that under average conditions the results are good both for the old and new supplies. In general the percentage removals are better for the old plant, which is readily explained by the fact that the old raw water was much more highly polluted than the new. With high pollution the figures for percentage removal will be high. This efficiency was only attained by the application of large doses of alum. In tables of this kind it is not possible to show how, in October, 1921, the B. coli index on the treated water rose to 1.9 per 100 cc. as a result of a heavy load of pollution. At about the same time the chloride content of the water rose to nearly 4000 parts per million. These were among the factors which forced Wilmington to seek a new supply. Referring to the tables it will be observed that the disinfected water had a higher count than the filtered water during the five-month period for 1922. This was due to after growths following chlorination, a condition which has not been troublesome since the new supply was put into service.

TABLE 1

	BACTERIA PER CUBIC CENTIMETER AGAR 37°C.	B. COLI INDEX PER 100 CC.
1922 (five months)		
Raw water	1,587	3,282
Basin effluent	121	
Filter effluent	46	27.7
Disinfected effluent	65	0.46
1923 (five months)		
Raw water	655	160
Basin effluent	126	
Filter effluent	65	0.77
Disinfected effluent	8	0.014
1920–1922 (three years)		
Raw water	1,806	2,166
Basin effluent	150	
Filter effluent	43	37
Disinfected effluent	23	0.39

TABLE 2

Percentage removals

	BACTERIA PER CUBIC CENTIMETER	INDEX PER 100 CC.
1922 (five months)		
By sedimentation	92.5	99.2
By filtration	62.0	
By disinfection	−41.4	98.3
Total	96	99.9
1923 (five months)		
By sedimentation	80.8	99.5
By filtration	48.4	
By disinfection	87.7	98.2
Total	98.8	99.9
1920–1922 (three years)		
By sedimentation	91.7	98.3
By filtration	71.4	
By disinfection	46.5	98.9
Total	98.7	99.9

In table 3 the average figures for five months of 1922 and 1923 respectively have been substituted in Streeter's formula, $E = cR^n$.

TABLE 3

Streeter's formula, $E = cR^n$

For 37° agar count: $c = 0.23$, $n = 0.55$.
For index per 100 cc: $c = 0.29$, $n = 0.30$.

	RAW WATER		FINAL EFFLUENT			
			Total bacteria at 37°C.		Index	
	Total bacteria at 37°C.	B. coli index	Found	Calculated	Found	Calculated
1922 (five months)	1,587	3,282	65	13	0.46	3.0
1923 (five months)	655	160	8	8	0.014	1.3

TABLE 4

Materials, labor and costs

	THREE-YEAR AVERAGE (1920–1922)	COST PER MILLION GALLONS	FIVE MONTHS AVERAGE (1923, MAY TO SEPTEMBER)	COST PER MILLION GALLONS
Filter plant				
Water filtered average, million gallons daily	3.230		3.183	
Wash water gallons per million gallons	27,000	$1.67	14,900	$0.76
Alum, pounds per million gallons	407	7.77	218	3.75
Lime, pounds per million gallons	113	0.82	37	0.28
Chlorine, pounds per million gallons	5.55	0.42	3.84	0.27
Coal, pounds per million gallons	2,340	8.49	133	0.43
Power, kilo-watt hour per million gallons			495	9.15
Labor, per million gallons		9.06		8.19
Total cost of purification, per million gallons		$28.23		$22.83
Pressure pumping				
Coal, per million gallons		$16.98		$0.85
Power, kilo-watt hour per million gallons				18.32
Labor, per million gallons		14.25		9.32
Total, per million gallons		$59.46		$51.32

This formula was derived from the examination of a large amount of data on filter plant performance and it indicates what may reason-

ably be expected from a well operated filter plant. It will be seen that for 1922 the bacterial removal does not reach Streeter's figure, but that the B. coli index exceeds it. The results for 1923 check the formula for total bacteria, but greatly exceed it in B. coli removal.

From the above considerations it appears that the improved plant is fully up to the standard that may be expected of a well operated filter plant as regards bacterial removal. From the point of view of physical appearance the turbidity has been reduced from an average of 69 to 0. With the old colored water the color removal was from an average of 151 to an average of 13.

Table 4 shows the relative amounts of material used to purify the two waters and the cost of each item. Separate figures are given for the cost of pressure pumping. The totals represent the actual cost of purifying the water and of delivering it to the mains. On chemicals the saving effected is roughly as follows, in percentage: alum, 46; lime, 70; chlorine, 30. The saving in wash water is nearly 45 per cent. The cost of pumping is about the same for the low lift pumps, but there is a saving of almost $3.00 per million gallon on the pressure pumping due to reduction of personnel. The total saving on the filter plant amounts to $5.40 per million gallon or about $18.00 per day. The saving effected on the entire process is $8.14 per million gallons, $26 per day or about $9500 per annum. Add to this the saving due to discontinuing the operation of a sewage pumping station designed to prevent pollution of the old raw water, which amounts to nearly $5000 per year, and we have saved enough to pay the interest on the bonds issued for the improvements.

In closing, the writer would like to request all the superintendents to compile their records for filter plant efficiency and cost of operation so that when we meet next year we can compare these figures. In this way we might arrive at a standard of comparison which would be of mutual advantage to operators and to the cities they represent.

YIELD OF WELLS[1]

G. C. HABERMEYER[2]

The State Water Survey Division has secured considerable information in regard to the yield of wells in this state. The yield, within certain limits, depends upon the depth to which the water level is lowered so information in regard to water levels is secured when possible. In the short time available I shall attempt to demonstrate the various pieces of apparatus used to measure depths to water as they are described.

When actual tests cannot be made information is secured in regard to the capacity of pumps, the depths at which pump cylinders are placed, the lengths of air lines for air lifts, and starting and operating pressures of air lifts. The capacity of a pump in a well gives the maximum possible yield of the well as operated, the depth of the pump cylinder with some allowance for suction pipe below the cylinder gives the maximum depth to which the water level can be lowered, and the length of air lines and air pressures when using air lifts give some information in regard to water levels.

It is usually possible to secure information in regard to yield by measuring the discharge in a reservoir, by noting meter readings where meters are installed, or by counting pump strokes.

A small yield may indicate little water available or it may indicate poor condition of pumping equipment. A lowering of the yield may be due to a partial exhaustion of the supply, to cave-in in the well, to deterioration of casing, or to deposits on and in the walls of the well due to reactions of waters. Fine sand drawn against a screen often greatly reduces the yield of a well into sand and gravel. Many of the waters in sand and gravel contain considerable iron and when the water level is drawn down below the screen air is allowed to gain access and deposit may be formed which may clog the screen and the material close to the screen. It is probable that considerable iron deposits are also formed in some deep wells in rock. At

[1] Presented before the Illinois Section meeting, March 20, 1924.

[2] Engineer State Water Survey Division, Urbana, Ill.

Mendota wells into rock are cleaned of such deposits regularly twice a year by forcing a scraper to the bottom.

The reaction of waters is referred to in a report made in 1910 to the city of Rockford by Alvord, Maury and Mead, in bulletins of the State Geological Survey Division, and by well drillers. This may be caused by a lowering of the water level or by a mixing of waters. In some wells the water level is lowered a considerable distance below the level at which it stands when not pumping. This gives a corresponding reduction of pressure on the water which may account for the release of gases and with the release of gases, especially carbon dioxide, a reaction in the water. Many wells in rock in this state penetrate several water bearing strata. Analyses of waters from various strata show considerable difference in the mineral content and the waters from the various strata rise to various elevations. For example, in drilling a well when a depth of 100 feet is reached water may flow in and rise to 50 feet below the ground surface and when a depth of 1000 feet is reached another water bearing stratum may be entered and water may then stand at 150 feet below the ground surface. Water from the stratum at a depth of 100 feet, unless cased out, will then be flowing into and downward in the well and may react with water in the stratum at the bottom of the well causing deposits on and in the walls of the well.

When possible it is very desirable in testing the yield of a well to determine the water level, not only in the well pumped, but in other wells or test holes in the vicinity in order to determine not only the yield of the well but the amount of water available and thus also to secure information in regard to the condition of the well pumped.

Various methods of measuring to water level have been referred to at previous meetings. I remember particularly discussions by Mr. Burdick, Mr. Enger and Mr. Beauchemin.

A simple arrangement is to use a wood float preferably weighted at the bottom so it will be held vertical, reducing the tendency of wedging in the well.

The depth can be determined readily by lowering a weight and noting when it strikes the water, if other noises nearby are not too great.

Mr. Beauchemin has referred to lowering a rubber hose. When the lower end reaches water and is lowered an increase of pressure may be noted at the upper end of the hose.

A good method for regular installation is to place a small pipe of known length into the well and attach an air pump and a gauge. When pumping at a slow rate so that friction is negligible the pressure when the gauge becomes stationary is the pressure required to force water out of the pipe. Deducting this from the length of the pipe gives the depth to water. At least one pump company is leaving apparatus practically the same as we have here as equipment with some of their installations. The University of Illinois has an air pressure line connected to the pipe and the gauge so hand pumping is not necessary and the pressure can be read at any time.

A magneto, which as used is practically a small dynamo turned by hand, may be used. Current is carried from one terminal on the magneto through an insulated wire which is lowered in the well. The end of the wire is protected to prevent it from touching the well casing. When the water level is struck current flows through the insulated wire, through the water to the well casing, and up through the casing or the ground to a connection which must be made from the casing or the ground back to the other binding post of the magneto. When the circuit is completed the bell of the magneto rings.

When traveling from city to city we must limit the weight carried as much as possible. Recently we have generally used an electric lighting circuit when it is available. An insulated wire carrying the current is run to a lamp and an insulated wire connected to the other terminal of the lamp is lowered into the well. When the lower end of the wire, which is protected from contact with the well casing, touches water the lamp is lighted. Electric wiring in many cities including Urbana is not all that it should be. Two wires are connected to each lamp socket and as installed it is a guess which one is carrying the current to the lamp. In order to save time we use an extension cord with one wire fastened to one lamp socket and the other wire fastened to another lamp socket. A bulb is first placed in one socket and the other terminal of that socket is connected to the ground. if the lamp does not light it is connected to the wrong wire and is put over into the other socket. Insulated wire is then connected to the second terminal of the proper socket and lowered into the well until the water level is reached as determined by the lighting of the lamp. Sufficient weight is placed on the lower end of the wire to hold it straight. The Kewanee Boiler Company has a very good apparatus of this type with the wire on a reel and the lamp socket on the side of the reel.

Mr. Bushnell and Mr. Marquardt of the Champaign-Urbana Water Company lower a wire through a small pipe placed in the well which keeps the wire straight and prevents contact with casings.

Travelling from place to place, with rough treatment of insulated wire when measuring, unwinding, winding, scraping over couplings and edges of well casing there is danger of partially destroying the insulation and allowing the current to flow from the wire at such place to the well casing or pipe flange, especially after the line is wetted. We carry at all times a protected float which can be used when there is doubt of the insulation of our wire, when there is no lighting circuit available, or where water is flowing downward in a well from a stratum above water level and might close the circuit with the electric apparatus that has been demonstrated. With this apparatus a low voltage current from one or two dry cells is connected in circuit with a buzzer or bell and two wires which are lowered into the well. The wires end in a tube in which small holes are drilled near the top and the bottom to allow air and water to flow in or out. A float held vertical with an electric conductor at the top (in this case made from a ten cent piece) is placed in the tube. When water is reached the float rises and the conductor at the top touches the terminals of the two wires, thus closing the circuit, and the buzzer operates. Very good contact must be secured to ring a bell or operate a buzzer. There is little danger from poor insulation and to save weight we use one wire insulated and the other one uninsulated. There is danger of too much insulation due to slight corrosion of the points and these must be kept bright. Mr. Siebert, Superintendent at Riverside, has used an apparatus similar to this for many years.

When we travel in auto we sometimes carry this apparatus which has the wires on a reel. The shaft is in two pieces insulated from each other with one wire connected to one piece of the shaft and the other the wire connected to the other piece of the shaft. The buzzer and dry cells are packed compactly in the box. This is arranged to use with the two wires and the float, but may be used with a lighting circuit using the insulated wire only.

DISCUSSION

M. M. SYMONS:[3] We operate wells with the water bearing strata approximately 90 feet below the surface. We drill from 50 to 60 feet below this stratum in the shale for submergence. We have an Indiana air lift, and to determine the draw-down or level of the water, the air pipe that connects to the pump has a tee on it and on that we have an ordinary steam gauge graduated to 1 pound graduations. We tried to regulate the air with an ordinary globe valve, which was not successful, so we put in stop cocks and by making a mark on the stop cocks, we could get a more satisfactory control. It was a simple matter to shut off the globe valve and to get the draw-down, and take measurements for the water. After being in operation for thirty-six hours, there is a draw-down of from 30 to 35 feet. In some of the wells it takes 80 pounds air pressure to start them, and then from 43 to 47 pounds will operate them nicely. We find that about 60 to 65 per cent submergence is the most economical point, but with us it was not economy; by increasing the air we can increase the output of the wells.

When we clean our screens, we shut off the discharge and turn in the air pressure at 100 pounds, which will come up sometimes 8 to 10 feet from the well; a great many times right up around the casing. This blows the sand back from the screen. Then when the well is released, the sand rushes in through the screens, cleaning off the accumulated iron on the screens, leaving the coarse gravel outside the screens. By doing this every few days, we find the well gives a better flow, and does not clog the screens. When blowing this well, we sometimes get shale and accumulated iron, as this shale comes from the lower strata.

[3] Chief Engineer, Interstate Water Company, Danville, Ill.

OBJECTIVE, POLICY AND PROCEDURE OF THE NORTH CAROLINA STATE BOARD OF HEALTH IN WATER SUPPLY[1]

By H. E. Miller[2]

As a result of the vision and foresight of our distinguished past president, president, president elect and certain other progressive engineers, waterworks men and public health officials, certain laws were enacted by the General Assembly, creating for the State of North Carolina what are commonly known as the State Water Supply Laws.

The first of these was the law requiring quarterly inspection of water sheds of public water supplies secured from streams and waterways. This law was enacted in 1899.

Next came the law requiring monthly analysis by the State Laboratory of Hygiene of samples of water from public water supplies, enacted in 1905.

Then in 1911 the law was enacted requiring State Board of Health approval of plans for proposed water works and sewerage improvements. This law specifies also certain other duties of municipality and state respectively in connection with water supply protection.

The foregoing laws have not been materially added to or amended since the enaction of the law of 1911.

It is a fact worthy of mention that the North Carolina water supply laws not only antedate similar laws in most other states, but that, even with the rapid growth and development of the state, they seem quite adequate for the control of the major water supply and sewerage problems of today.

The State Board of Health is designated by these laws as the State agency responsible for their administration. Since all regulatory statutes must define duties and responsibilities for the governing agency as well as for the governed, there are imposed upon the

[1] Presented before the North Carolina Section meeting, November 14, 1923.

[2] Director, Bureau of Sanitary Engineering and Inspection, North Carolina State Board of Health.

State Board of Health certain specific duties and responsibilities with regard to public water supply. It is the purpose of this discussion, therefore, to set forth in the broadest sense an interpretation of our responsibility in this connection, and to indicate wherein you may profit by taking advantage of the facilities which the State, through the State Board of Health, has placed at your disposal. In the June issue of the Health Bulletin the legal wording of the statutes is translated into current English, and the respective duties of State and municipality are defined and explained. Time will therefore not be consumed here in repetition. It is suggested, however, that all those whose duties are in any way connected with public water supply management secure copies of the June Bulletin.

There can be only one purpose for all health legislation and one objective of any state public health agency, which is, necessarily, to protect the public health. Inasmuch as the fundamental principle of public health practice is based upon the recognition and correction of potential dangers to health, no half way measures or partial protection can be accepted or condoned if protection of the public health is to be effected.

The application of safe standards of protection to the various classes of supplies will now be considered.

GROUND WATER SUPPLIES

Given a source of supply located as remotely as possible from developed sections of the community or sections that are likely to develop with good, natural and artificial drainage, with satisfactory details of pump pit drainage, and attachment of pumps to casing, and with rigid control of sanitary conditions around the source, in short with all visible evidences or possibilities of pollution removed, the supply should be safe. Even occasional samples, however, from such a source showing the presence of B. coli on monthly analysis indicates such a supply to be potentially dangerous. If the cause of the presence of B. coli cannot be located and remedied, the continued use of the supply constitutes a menace to health and the abandonment of the source of supply is imperative. In the meantime chlorine sterilization of all water used from such source is an essential safeguard.

SURFACE WATER SUPPLIES

Unfiltered. This class of supply is found only in the mountain sections. The watersheds are uninhabited and trespass of any kind is prohibited by State regulations and patrol. The raw water of this class of supply is normally pure, but there always remains the possibility of trespass which constitutes a potential danger.

Filtered. This class of supply is found principally in the central and eastern section of the State. The raw water of this class of supply is normally impure on account of the character of the watersheds, on most of which farming, timber, cutting, etc., are extensively practiced. In some instances the waterway used as the source of supply receives the sewage of one or more municipalities upstream. This type of supply therefore requires effective filtration to remove impurities. If the filter plant is properly constructed, it can and should remove all pathogenic or disease germs at all times, as indicated by B. coli, provided the operation of the plant is conducted under sufficient rigidity of check and control. It is believed that this measure of efficiency is a reasonable and essential requirement of filtration.

At this point the raw water of the normally pure surface supply, used without filtration, and the filter effluent of the normally impure supply requiring filtration are on a par value of safety.

Both supplies are at this point, however, potentially unsafe, the first because of possible trespass upon the watershed, and the second because of possible decreased plant efficiency, due to the failure of certain items of plant equipment to function to the maximum degree of efficiency, or some failure on the part of the operator. A second line of defense or measure for insuring uniformly safe quality of water is therefore imperative to offset the potential element of danger. This is accomplished by some form of sterilization or disinfection, such as chlorine, either liquid gas or bleach, ultra violet ray, ozone, etc. Since chlorination is the simplest and cheapest process of sterilization, it has been most extensively practiced. Both the liquid gas and bleach process of sterilization are being used satisfactorily.

In the case of any supply the fact that sterilization is being practiced is no valid reason or excuse for relinquishing the utmost diligence in protection of the watershed or maintenance of *maximum* efficiency of filtration, because chlorination would then become a

purification or primary process of treatment, constituting the one and only line of defense, and the element of potential danger would still exist.

In striving to attain a safe standard of water supply protection throughout the State, the responsible State agency must recognize the necessity of definitely established policies, by means of which it is proposed that the attainment of the objective shall be accomplished.

The government of our State is founded upon the principles of democracy and local self government. Consequently, it is neither the purpose of the State laws nor the policy of the State Board of Health to supersede local governmental functions or to interfere in any way with this principle.

Accordingly, the protection of water supply, is primarily a local responsibility. It is believed that the interests of the Stateat large can be served to the best advantage by coöperation to the greatest possible extent with the local officials on whose shoulders the responsibility directly rests.

Having established a policy of coöperation, it becomes necessary to determine the plan of work or method of procedure from which the greatest benefit in water supply protection will be derived. It is believed that "service" is the answer to this question. Through the State Board of Health and its engineering staff, therefore, the State is prepared to assist the municipality in matters pertaining to water supply protection. Some of the items of service that are thus made available are advice or helping to secure information, assisting to secure necessary water supply improvements, helping you to improve your system of plant operation, or assistance in any other capacity that we may be able to serve without encroaching upon the field of the practicing engineer.

To summarize briefly, the State Board of Health has a definite objective which is "safe water supplies," a well defined policy which is "coöperation," and a standard method of procedure which is "service."

ACCURATE CONTROL OF AN OLD FILTER PLANT[1]

By Earle G. McConnell[2]

In presenting this paper I shall endeavor to describe, in a non-technical way, the advantages gained at Charlotte through the accurate control of its old filter plant. It should be remembered, however, that the various means devised meet the conditions at the Charlotte plant and may or may not be applicable to other old plants. As our new plant was scheduled to be in operation the first of the year, it was not advisable to go to any appreciable expense for control apparatus.

The city of Charlotte obtains its water supply from the Catawba river. The river pumping station is located 11¼ miles from the city. It contains two electrically driven Morris centrifugal pumps, each having a capacity of 3500 gallons per minute or a combined capacity of 10,000,000 gallons per day.

The river pumps discharge into a settling basin which is located 5 miles from the city. This basin has a capacity of 60,000,000 gallons and allows a plain sedimentation period of approximately seven days. The outlet crib has openings at three depths, thus allowing the water to be drawn from near the surface regardless of the water level in the basin.

From the settling basin the water flows by gravity to the filter plant, which is located 1¼ miles from the center of the city, and enters the coagulating basin under a head of 140 feet. The coagulating basin is 100 by 200 by 10 feet deep and has a capacity of 1,500,000 gallons. It is divided into two equal compartments, allowing the plant to operate one compartment when it becomes necessary to clean the basin. Each compartment contains three around-the-end baffles placed on 25-foot centers and the end of each baffle is 18 feet from the opposite side of the basin. This gives the water a lineal traveling distance of about 850 feet. Since the maximum flow of water through the basin is estimated to be at the rate of 8,000,000

[1] Presented before the North Carolina Section Meeting, November 15, 1923.

[2] Superintendent of Filtration, Charlotte, N. C.

gallons per day it allows a minimum retention period of four and one-half hours. However, with the average consumption 4,700,000 gallons per day, the average retention period is seven and one-half hours.

Alum and lime are used as coagulants. Solutions of each enter the raw water at a uniform rate, the dosage being controlled by addition of the required amount of each chemical to its solution tank at fifteen-minute intervals. Unslaked lime in barrels is purchased in 60-barrel lots and is slaked, a barrel at a time, just before use. Seventeen per cent lump filter alum is used and is purchased in car load lots. The alum and lime solutions enter the raw water line 50 and 75 feet respectively from the entrance to the coagulating basin. The raw water with its doses enters at the bottom of the basin, through a 16-inch 45-degree bend turned up, under 60 pounds pressure, causing the water to roll and tumble and giving an excellent mix between the water and the chemicals.

It may be easily seen that, with no raw water meter, and with such an inadequate method of applying coagulants, the control of dosages and the flow of raw water was a problem. Since there is only one solution tank for each chemical, with no means of controlling the flow of the solutions the feeding of solutions of constant strength through orifices was out of the question. It has been the custom to add enough alum and lime to the solutions tanks to make the water "look right," with no regard for the amount of raw water being treated. Of course, the necessary apparatus for proper control could have been installed, but since our new plant will be ready the first of the year and the present plant has been operated for the past ten years under these conditions, it was decided that, if a satisfactory means of control could be devised, any new installations for such a short period would be inadvisable.

Since there was no meter there had to be some means of controlling the flow of raw water in order to know definitely the amount that was being treated. The raw water is fed into the coagulating basin through a 6-inch gate valve. After careful observation of the maximum and minimum amounts of water required for the distribution system together with the flexibility of the plant it was found that we could operate satisfactorily by using three settings on the 6-inch valve. To explain in detail—this valve opens completely on fourteen full turns. By using three settings of fourteen, eight, and five turns we can have the water enter the basin at one of three definite rates of flow.

In order to get an accurate control of the chemical doses two sets of sheet metal cans were obtained, one set for alum, the other for lime. Each set has 8 cans which are plainly numbered from 1 to 8 and range in size from 4 to 10 inches square. The sizes are calculated so that any series of three cans will take care of the fourteen, eight, and five turns on the raw water valve. For instance, alum cans 6, 7, and 8 will take care of fourteen, eight and five turns on the 6-inch valve when the turbidity of the raw water is 100 p.p.m. When the turbidity changes to 200 p.p.m. then cans 5, 6 and 7 are required. The can in use is filled level with its chemical and added to the solution tank at fifteen-minute intervals. A small blackboard was put up at the chemical house and day by day the numbers of the cans required, which vary according to the character of the water, are placed opposite the fourteen, eight, and five turns. It has been found that turbidity is the most uniform determining factor of the amount of coagulant required for Catawba river water, so a chart has been made showing the cans required for various turbidities. The men who feed the chemicals have been taught to measure turbidity with the United States Geological Survey turbidity rod and then refer to the chart for the numbers of the cans that correspond to the turbidity measured. In the absence of the plant operator they may readily adjust the doses should a change in the water occur. Under ordinary conditions this method works admirably. However, at first what might be termed the human equation of the men was overlooked. It was a difficult, if not impossible, task to get ordinary labor that could be depended upon to get the chemical charges in on time. They would invariably be a few minutes early or late and often during the night shift would miss charges altogether, the result being that the water would be underdosed and a turbid filter effluent would result. They would then attempt to correct their negligence by adding extra charges resulting in an overdose and a waste of chemicals. This problem was solved by getting an ordinary watchman's clock and requiring the men to punch the clock each time they charged. The plant now has an undeniable record of every charge of chemicals for months back and the men absolutely cannot neglect their work without being detected. It might be of interest to add that the night shift man was discharged within a week after the clock was installed. The saving in chemicals effected through regularity of feed more than paid for the clock the first month. The result of its use has greatly increased the quality of the filter effluent.

The outlet from the coagulating basin to the filters was formerly a 16–inch cross at the bottom of the basin. This pulled the water from the bottom and gave the basin a very low efficiency and caused an excessive amount of wash water for the filters. A brick well was built around this outlet and its height brought up to 30 inches of the average level of water in the basin. The result was a 25 per cent increase in the efficiency of the basin and a reduction of about 25 per cent in wash water for the filters.

We have 10 wooden tub gravity filters with mechanical stirrers. Each has a filtering surface of 177 square feet making a total filtering surface of 1770 square feet. Upon examination it was found that about 25 per cent of the sand surface was covered with foreign material such as cinders, wood chips and small pieces of coal. This caused not only a very irregular, but a reduced filtering surface. Each filter was thoroughly scraped and cleaned and all are now giving very satisfactory results. With old type filters such as those at Charlotte one of the greatest problems is to get a good wash. They have no rewash, filtered waste outlet, loss of head gauges, or rate controllers. Washing the filters was invariably followed by a turbid effluent until a sufficient mat was formed on the surface of the sand to make a good filtering medium. It was observed that under normal conditions the peak of the load occurs around noon and gradually decreases until about 6:00 a.m., when it begins to pick up again. Due to lack of flexibility of the plant, anywhere from 2 to 10 filters are required during the twenty-four-hour day. The 10 filters were divided into two sets of 5 each, the first set being washed at 4:00 p.m. and the second set at 4:00 a.m. This is based on a twenty-four wash which has been found to be ample under normal conditions. After the first set is washed in the afternoon, they are allowed to stand idle full of coagulated water until the next morning when the second set is washed. Those needed are then placed in service and the second set cleaned and allowed to stand until such time as they are needed for service during the day. By this method it may be seen that we have all our filters clean for the day run and by standing idle for a few hours the filter tends to settle and a slight mat forms on the sand surface, so that, when they are put into service they give a much brighter effluent than if they were put into service immediately after washing. In fact it is difficult to detect in the total filter effluent when the clean filters are placed in service.

We now come to the important question of what has been the result of these rather crude methods of attempting to place this old type filter plant under accurate control. First of all, the quality of water produced has exceeded all expectations, both as to physical and bacteriological standards. The filter effluent is clear and bright at all times and with but two exceptions during the past four months has passed the Treasury standard for a sanitary water before being chlorinated. The saving of coagulants is shown in the following table:

MONTH	AVERAGE TURBIDITY	ALUM	LIME
	p.p.m.	*gr./gal.*	*gr./gal.*
June	275	3.0	1.1
July	250	1.0	0.3
August	575	0.9	0.18
September	525	0.8	0.08
October	210	0.7	0.0
November (twelve days)	90	0.4	0.0

A conservative estimate on the saving in chemicals is $5000 per year. There will also be other economies in the general operation of the plant such as wash water, coal, oil, and so on. Experiments are now being conducted to ascertain if sulphate of iron can be used on Catawba river water. If these experiments are successful and sulphate of iron substituted for sulphate of alumina, there will be a further saving in the cost of coagulant. While these experiments are not far enough advanced to come to any definite conclusions, indications are that iron can be used on this water.

Though these various mechanical methods and devices have contributed to the control of this old type plant, any success that has been attained has been due to the fact that the plant has been operated under strict laboratory control and the results of laboratory tests have been *interpreted* and applied directly to the operation of the plant. It is not meant by this that a lot of unusual highly technical analyses are made. Only the ordinary physical and chemical tests for turbidity, color, alkalinity, carbon dioxide, hardness, and hydrogen-ion concentration are made and the bacteriological tests for total bacteria and B. coli. In coagulation the optimum point can only be determined by laboratory tests and can be held at this point only through the strict interpretation of laboratory tests, the result being that the water is being properly treated at a minimum expense for coagulant.

Some plants are still attempting to operate without any form of laboratory control whatever. Such operation should be prohibited, for an improperly operated water plant is a great menace to public health. The reason for this apparent indifference on the part of the public lies in the fact that they cannot see or comprehend the hidden danger that lies in a clear sparkling glass of polluted water. The writer firmly believes that, if they did understand the ever present menace of having their water supply coming from a plant that is operated by guess work, we would have more rigid requirements governing such operation.

There are other plants that make all the necessary chemical and bacteriological tests, but do so mainly as a matter of routine and record. There are extreme cases in municipally owned plants where a good laboratory and technician has been acquired as a screen behind which to hide an inefficient political henchman in a soft job. Other plants have the work done through their city board of health. Such tests, of course, are valuable as a matter of record and for ascertaining the quality of water being furnished the consumers at any particular time, but, unless these tests are interpreted, they are of little value in the successful and economical operation of the plant, The technique of making these tests is very simple. In fact any intelligent person can soon learn to make them accurately, but only a man who understands the basic principles of water purification can make the proper interpretation of these tests. In other words, a plant should, by all means, have a laboratory, but not a laboratory alone. It should have a trained man capable of making and interpreting all the necessary tests and occupying such position in the plant that he can apply these interpretations and direct the operation of the plant accordingly.

Plants that are operated without rigid control invariably tend to rely upon chlorination as the means of producing a safe water. They attempt to use emergency measures in the routine operation of the plant. There can be no doubt as to the value of chlorination under proper control. It has probably done more to insure sanitary water supplies than any other one process ever developed in water purification. But, by chlorinating a distinctly turbid water, it can be made safe from a sanitary standpoint without any further treatment whatever. The practice of allowing the water to pass through the coagulating basins and filters with little thought as to its quality, feeling secure in the knowledge that a dose of chlorine at the end of the process will make the water safe for consumption is, in the writer's opinion,

placing water purification upon a false foundation. If the proper chemical dosage is applied and the basins and filters are operated efficiently, the filter effluent should show no turbidity and should be sanitary. It should then be followed with a dose of chlorine merely as a precautionary measure.

The ideal plant from the operating standpoint has a good laboratory and has a competent and trained man in charge of its operation. A plant so operated is the best health insurance a community can carry. At the same time this important public utility is being operated at its maximum efficiency.

CROSS CONNECTIONS[1]

By M'Kean Maffitt[2]

There has been so much said and so little done about cross connections in public water supply systems that it is hard for me to know where to start. It is harder to know what to say and hardest to know where to stop.

Cross connections are private water supply systems that are connected with the public water supply system. They exist in most of the cities and towns of the country where there is a public water supply and it has been shown that they are a menace to health. To my mind it has been proved beyond a doubt that they should not exist in such a manner that it is possible to get polluted water back into the public water supply from the private supply. Unless some immediate action is taken towards the elimination of these connections, and their prohibition in the future, they are going to increase as the industrial development of the communities increases. As I shall show later, every such cross connection is a positive and continuous source of danger to the public water supply system where there is a possibility of poluted water getting into the public water supply.

I would not place a burden on any industry by forcing it to do that which was not necessary for the protection of the health of the community. Nor will I knowingly allow industry to place any additional or unnecessary dangers upon the public water supply system. Therefore the question is, "Shall industry, for a small monetary consideration, endanger the health of the entire community; or shall industry spend a few hundreds of dollars in each individual case and free the community from a constant danger?"

If the heads of the various industries could see what they are doing in maintaining these connections, they would be tempted to force the responsible water works official out of office for allowing these connections to have been made.

[1] Presented before the North Carolina Section meeting, November 14, 1923.

[2] Superintendent of water, and City engineer, Wilmington, N. C.

My own experiences with cross connections show that they are very dangerous. Though my experience has been limited as compared with that of others, I am still of the opinion that such connections should not be allowed to exist.

In one case we had a 16 inch valve to cut in the line. Considerable trouble was experienced in getting a dry pipe so that we could work. We went over the valves several times, but failed to find the one that was leaking. Yet we knew that there was either a leaky valve or an unknown connection. The flow of water in the hole was about 200 gallons per minute. Remembering that there was a cross connection supplied from the section cut off we went to this connection and closed the gate valve on it. The flow of water ceased immediately. The check valve was leaking so badly that the private water supply system could not keep the pressure up and we were getting all of the water into our lines. Knowing this we took immediate steps towards the repairing of this valve and the washing out of the mains affected. Otherwise we should have had a polluted water supply and we would not have known where it came from.

This cross connection took water from the river within a few hundred feet of the largest sewer in town and at flood tide the sewage was carried up to the intake of the pumps. If increased pressure on the pipe lines on this cross connection had been necessary and had that pressure been above the city pressure we would have had the same trouble that so many other cities have had.

In another case we had a blow out at the pumping station that caused the water supply to be cut off for an entire day. During this time all of the private water supplies had their pumps running, which was a legitimate thing for them to do. Immediately after the supply was cut off I sent to all of the private supplies and had the gate valves controlling them closed. This was done as a precautionary measure. Had the gate valves leaked, as so many of them do, it would have been of little avail. At one connection, the foreman in looking for the gate valve opened the meter box and noticed that the meter was running backwards. How much water had run into the public supply system we do not know. This happened on a long dead end of 12-inch main and we were able properly to wash out this main as soon as the water supply was turned on again. We did not have, therefore, any trouble with this pollution.

These two cases show that it is possible to have leaky valves without being aware of it. If this condition does exist, some day you are going to get polluted water into the system and, for the time being, all the money that you have invested for a purification plant will be thrown into the discard and you may as well be pumping raw water.

If we do not make it impossible to get polluted water into the public water supply system, here is what may happen to your own city. These are just a few cases used as illustrations because they are so obvious in their results. There may have been many more that were gradually letting pollution into the water supply and were never detected.

Lowell, Mass., 172 cases typhoid, 9 deaths, and many cases dysentery
Lawrence Mass., Many cases typhoid, many deaths, many cases dysentery
Bloomington, Ill., 130 cases typhoid, 15 deaths, 400 cases dysentery
Rochester, N. Y., Many cases typhoid
Boston Mass., Several cases typhoid, deaths unknown
State of Rhode Island, 40 cases typhoid, 4 deaths
Franklin, N. J., 114 cases typhoid, 18 deths
State of Illinois, 800 cases typhoid, 75 deaths (5 outbreaks in state)
Rockaway, N. J., 41 cases typhoid, 4 deaths
Total of 1297 cases and 125 deaths of typhoid fever.

We know what caused these deaths. Are we to sit supinely by and let the other side say that these cross connections are not dangerous? They are dangerous and the sooner we see it and make it impossible to let this pollution into our water supplies the better will we be able to rest at night.

The insurance interests say that the check valve as designed and approved by them is sufficient to protect the water supply. If it is, how can you account for the following:

There have been reported,

19, plus many, check valves as leaking
3 gate valves as leaking
61 F. M. check valves as leaking in one valve
6 F. M. check valves as leaking in both valves
25, plus many, outbreaks of typhoid fever due to cross connections
4 outbreaks of fever due to by-passes
5 outbreaks of fever due to intakes
1 case contamination due to cross connection with deep well
1 case of F. M. check valve being held open by pair of overalls

If the public health is insufficient to cause drastic action, how about the financial costs of the epidemics. Taking the case at Lowell, Mass., with 172 cases and 9 deaths, Caleb M. Saville, Chief Engineer, Hartford, Conn., Water Board, estimates the costs at $100,000.

The question of a double supply of water for fire protection, one from the city supply and one from a polluted supply, where there is no physical connection between the two, has been solved by the over feed tank where the inlet pipe from the public water supply is higher than the over-flow pipe from the tank and where the over-flow pipe from the tank is so large that the fire pumps can not fill the tank to the supply pipe from the city supply. In this way, and as far as I can see in no other way, can we be assured that there will be no pollution from the private supply that can get into our mains.

Mr. President, I move that this Association go on record as follows:

There shall be no physical connection between the public water supply system and any private water supply system, wherein it is possible for contaminated water to pass to the public water supply system.

HENDERSONVILLE, N. C., GRAVITY WATER SUPPLY SYSTEM[1]

By Stanley H. Wright[2]

The city of Hendersonville lies on a plateau west of the Blue Ridge Mountains at an elevation 2250 feet above sea level. The city is situated on the main line of the Southern Railroad between Cincinnati and Charleston, 100 miles west of Charlotte, N. C. The permanent population is about 6000, but during the summer months the population increases to from 12,000 to 15,000.

The original water works, consisting of a crude reservoir fed by two small streams, was constructed in 1888 which by 1918 had become woefully inadequate. As a temporary measure a pumping station on another nearby stream was constructed and at this time a treatment plant installed. Even this additional supply did not give the amount of water required.

In 1921 the water commissioners of the city of Hendersonville, C. E. Brooks, Chairman, K. G. Morris, Secretary and Treasurer, and J. W. Bailey, in their interests for this community and the thousands of tourists that come to Hendersonville, procured what is said to be one of the finest water supplies east of the Rocky Mountains. The Commission is an appointed body distinctly separate from the other city officials. Through this Commission the State Legislature permitted the city to vote $600,000 in bonds to build a new water system, and in the summer of 1922 construction work began.

We think of pure air, wonderful skies and delightful scenery to be the natural attributes of any locality so fortunately placed that these things to the appreciative stimulate their minds and make their lives worth living. Water is usually so ready at hand, made available by the mere turning of a handle, that its quality, so long as it be clear, must often pass unnoticed.

So that all who so desire may drink their fill of natural water untreated, but absolutely pure and crystal-like in clearness, the city of

[1] Presented before the North Carolina Section meeting, November 14, 1923.

[2] Hydraulic Engineer, Gilbert C. White Co., Consulting Engineers, Durham, N. C.

Hendersonville has laid a 16-inch pipe line 17 miles west into the heart of the Pisgah National Forest Reserve. Here they have 20 miles of uninhabited water-shed entirely forest covered. Not a soul living upon the water-shed, nothing but the wild creatures of the forest which roam at will under the protection of the United States Government. Here one may find deer, bears, wildcats, ground hogs and many feathered creatures living without fear of mankind, as no one may enter the Forest Reserve who carries firearms.

At the junction of Big Creek and Fletcher Creek there has been constructed a masonry intake dam holding 5,000,000 gallons, at elevation 2450 feet above sea level. This dam diverts the water from the streams through the pipe line constructed over a private right-of-way into a distributing reservoir in Hendersonville.

The construction of the intake dam and pipe line involved many difficulties. The cast iron pipes, each piece weighing nearly a ton, had to be transported in many different ways to reach the rocky places so difficult of access. To deliver these pipes the contractors had to make use of trucks, tractors, 2-mule teams, 4-mule teams and oxen, while some pieces had to be lowered down precipitous sides by blocks and tackle. Up and down the hills, across many creeks and deep under the French Broad River, the pipe line is laid. Each mile of pipe is tested to see whether any pieces are defective or whether the joints are properly caulked. In some sections the pressure applied amounted to 250 pounds per square inch.

The intake dam is a masonry structure of the gravity type, built of cyclopean concrete with a cut stone face wall. It is located at the junction of Big Creek and Fletcher Creek; the two creeks at this point forming the North Fork of Mills River. Owing to the fact that the water in these two creeks is very clear and free from sediment, sand was unavailable, and it had to be imported from a source twenty miles away, making it cost, approximately, $9.00 a cubic yard. The stone for the face of the dam and for the concrete was quarried on the job. The difficult part in the construction of the dam was its inaccessibility. It is in a rough country and 20 miles from the nearest railroad. The last 3 miles before construction began was a foot trail up the river, fording it fifteen times. After the contract was let, the contractor widened the trail enough for a wagon to get through in dry weather. In wet weather it was practically impossible to do so with a load. A good team's capacity on this so-called road was ½ cubic yard of sand, or 12 bags of cement, making only three loads a

day. Because of this long haul of 20 miles with sand and cement, and the light equipment used on the job, namely, a small cableway and a quarter yard mixer, construction progressed rather slowly.

The dam is a small structure, 180 feet long and 22 feet high at the deepest place. It contains about 700 cubic yards of concrete. Nevertheless, it is considered one of the most beautiful masonry structures of its type in the state.

The reservoir formed by the dam has a capacity of 5,000,000 gallons. There was little need of an impounding reservoir as the two streams together flow more (in the driest time) than the capacity of the pipe under the present head. Above the lake on each creek heavy timber racks were built to catch all logs and trash which might come down in flood. Immediately below the dam a masonry house, built of round river boulders, contains the Venturi meter.

The transmission line was built of 16-inch cast iron bell and spigot pipe, furnished by the United States Cast Iron Pipe and Foundry Company. All classes of pipe were used from A through to E to take care of the varying pressures along the line. The construction of this line was difficult in places, owing to the rough topography. The 4 miles from the intake to the foot of the mountains were the most difficult. On the steep slopes, some at approximately 45°, it was impossible to get the heavy pipe along the ditch without the use of teams with block and tackle to snake the pipe into place. At the creek crossings the pipe had to be laid below the bed of the stream and anchored there with concrete. At the French Broad and Mills River, cofferdams were built, the pipe laid several feet below the bed of the streams and anchored with concrete. There was quite a large amount of rock excavation, although not excessive for the mountain country.

Some idea of the amount of work involved in this project may be had when it is realized that 215,000 pounds of lead had to be melted and poured into the cast iron joints. Two hundred freight cars containing 7200 pieces of pipe were shipped into Hendersonville.

On this transmission line there are gate valves, approximately every 5000 feet, to aid in charging and testing the line, and to operate in emergencies. Air valves were put at all high points in the line and blow-off valves at all low places. The air valves are automatic, but the blow-offs require the attention of a man twice a year to open and close them, thereby cleaning out the line. The pipe discharges 2,300,000 gallons per twenty-four hours.

The distribution reservoir was built on top of a hill 1 mile west of the city. It is elliptical in shape with a division wall across the center, making two separate basins. Water can be taken from either basin or both. The reservoir was built by excavating the inside and building enbankments with the material excavated. The inside slopes and bottom were concreted; the outside slopes and top sodded. The capacity of each basin is 2,500,000 gallons, which is a six-day supply at the present time for the city.

The distribution system consists of a 16-inch supply pipe from the reservoir to Main Street, with 4-, 6- and 8-inch laterals on the most important streets. More than 7 miles of new 6-inch pipe, and 1 mile of 8-inch have been laid. Fire hydrants have been set not more than 500 feet apart. Steamer nozzles were used in the business section.

The new system gives Hendersonville an abundant supply of clear, pure water at no expense, save that of construction. The following are some of the outstanding features in the construction of the gravity pipe line:

Total head between intake dam and distributing reservoir	117 feet
Working pressure in Hendersonville on Main Street	90 pounds
Total length of pipe line to distributing reservoir	77,000 feet
Total length of line into Main Street, Hendersonville	84,240 feet
Estimated capacity of pipe line from intake into reservoir	2,300,000 gallons
Actual measured flow by venturi meter	2,320,000 gallons
Leakage—None that can be observed or measured by meter	
Maximum static pressure at lowest point in the line	175 pounds
Maximum pressure to which line has been subjected	250 pounds
Number of split pipe placed in the line or failed under pressure was 3 out of a total of 7020 pieces	

There was one serious joint blow-out under pressure.

Only 3 per cent of the total number of joints showed slight sweating and trifling leakage which required re-caulking.

Water was turned into the pipe line within sixteen days of the contract time, in spite of delays due to the railroad strike of 1922 and to rainy weather.

The contractor used no mechanical equipment whatever, other than a gasoline pump and the hand-winch unloading derrick. The lead for the joints, aggregating some 265,000 pounds, was melted in pots on open wood fires. All the pipe handling and caulking was done by hand.

The Kelly-Wilson Company of Asheville, N. C., were the contractors for the pipe line and the Virginia Machinery and Well Company of Richmond, Va., were the contractors for the intake dam and distributing reservoir. Both contractors are credited with performing first class work in every respect. The Gilbert C. White Co., of Durham, N. C., were the consulting engineers.

WHY FIRE CHIEF AND WATER WORKS SUPERINTENDENT MUST WORK TOGETHER[1]

By Sherwood Brockwell[2]

Ordinarily in giving a fire prevention talk, one tries to fit it to his audience, but the fire chief and superintendent of water works, the water department and the fire department are so closely allied that the problems of the one automatically become the problems of the other.

Every large city in North Carolina has made or is at present making extensive additions to the present system. We have installed many plants in our smaller towns, but too many of our 4000 and 5000 towns have not improved their water works and fire department facilities in keeping with their unprecedented growth, and this calls for dilligent and intelligent work from the individual superintendent and water works associations in general.

Another point I want to call your attention to is that on my desk at present there is correspondence from five cities and towns in North Carolina which have installed water works systems within the past ten years and have put down paved streets. Now with the water works practically new, they are confronted with the necessity of removing the newly laid pavement in order to make necessary extension throughout their business districts, showing that someone in authority, from a water works standpoint, was either short-sighted or the municipality, not expected to be up on such problems, has been allowed to invest in something which should be of undisputed benefit and yet has derived little benefit from the investment.

Some weeks ago there was a fire in a thickly settled residential portion of a North Carolina town. When the fire department arrived, a two-story, frame dwelling was pretty far gone. One line was attached to a pumper of 750 gallons, which in turn was attached to the nearest hydrant, about 750 feet away on a 4-inch main and an effective fire stream was produced. Presently the chief de-

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[2] Fire Engineer, North Carolina Insurance Department, Raleigh, N. C.

cided to apply two lines and in a few moments both streams were idle. Before the trouble was located and remedied eight minutes had elapsed, a home was destroyed and a real serious fire narrowly averted.

Of course, no fair-minded man would have blamed the superintendent of water works for the chief of fire department using a flexible suction pipe, but that much property ought never to have been allowed to have been built up on a 4-inch main. There is an 8-inch line there now.

Another instance I recall was a furniture factory, located on the border of a thickly built residential section. When the department arrived, there was a great deal of smoke, but not much fire; 250 feet away there was a hydrant on a 4-inch main; 450 feet away there was a 6–inch main. The first line was stretched 450 feet off of the 6-inch main. Just as the water started a pumper was attached to the hydrant on the 4-inch, fed from the 6-inch main, and two lines stretched from this pumper. You know the result. As the pumper operated, the domestic pressure line went down. Then the second pumper was attached to the 6-inch main further up the line. Friction ate this line up while it was cutting all the others down. With both pumpers panting, the fire burned merrily on unmolested by an effective fire stream, while those whose homes were out of range stood by and cursed the fire department, water works, fire pumps, city officers and the whole works in general. In a following election they did defeat the three commissioners, the fire chief, and would have gotten the superintendent of water works had it not been for the fact that he is one of the best in the United States and absolutely the right man in the right place.

The superintendents are all ready to say that the chief was foolish and that the superintendent of water works was in no way open for criticism. The chief did the best he knew how. He did not know the difference between a 4-inch and a 6-inch main. A hydrant was to him a hydrant, that and nothing more.

I happen to know both men in this case personally. I know that the superintendent, a technically trained man, had spent hour after hour trying to explain those kinds of things to the chief, who, probably willing enough to learn, was incapable of taking such information. I know also that, in this day of modern water systems, there was no place for the 4- or even the 6-inch main.

There is no man in your town more capable of knowing the fire chief's ability than the superintendent of the water works, and I might add that the opposite is true.

The great difference lies in the fact that most cities have learned that the water works superintendent should have technical training before being appointed and have looked to this end when filling such positions, while the average fire chief is left to acquire his training after being given the responsibilities.

The point is that a large part of the water works business is fire protection. When we consider that there were 15,000 Americans burned to death last year and over five hundred million dollars worth of property destroyed, it is time for us to realize that, if your town is large enough to have a water works system, there are fire conditions existing therein, which require your putting shoulder to shoulder along side of the fire chief. Each must know his part and coöperate.

Your training puts you in the position of being the big brother in all things hydraulic. You will find the little brother anxious to do his part.

There never has been a good fire chief who did not appreciate the big brother attitude. There is no room in modern fire protection for either a chief or a superintendent who will not push for better water, more water protection in newly built-up sections, anti-combustible roof ordinances, public sentiment against promiscuous handling of gasoline, laws against sleeping quarters over garages, better buildings, safer schools, and hundreds of other things you two can accomplish together.

Too much of our state and national fire loss has been due to the lack of true coöperation between fire chief and water superintendent. One has been too prone to ignore the duty and limitation of the other and the other has too long been indifferent to the needs and problems of his brother in service.

There has been too much pressure gauge reading and fire report reading in the form of alibis. My closing plea is, fire protection is big enough for both of us.

DRILLING, CARE AND OPERATION OF DEEP WELLS[1]

By Chas. F. Cole[2]

The first thought that comes into the mind of the water works engineer is "Can we get a satisfactory surface source of water supply?" Frequently this is not available, particularly in the case of small towns and this is where the use of drilled wells flourishes. No deep well driller worthy of the name recommends drilled wells where the size of the town warrants an extensive and expensive water system from a surface supply within a reasonable distance. The exception to this rule is that in the coastal plain frequently a large yield of water may be obtained from a series of wells at moderate cost to supply towns of considerable size.

The second thought that comes to mind is, "What is the prospect of obtaining water from a well or wells and what is the best location for the well," always bearing in mind that the highest authority in the State, the State Board of Health, must approve the site of the well.

There is no fixed rule or set of conditions to guide us in locating a well so as to insure an adequate yield of water within a reasonable depth. It is largely a case of betting on your hand and a gambling chance to win.

However, there are certain suggestions I should like to present based on some twenty-five years experience and observation. It is not good practice to locate the well on high hills or ridges, nor in low dales or swamps—for the rocks conform to some extent to the surface topography and are more likely to be "hog backs" on hills or ridges shedding water and not have sufficient crevices or faults to permit of the seepage or filtration of water along these veins into the bore hole or well.

Placing a well in a low valley with surrounding hills means that the well frequently penetrates disintegrated and broken up formations which do not hold water. Further, quicksand or a fine running

[1] Presented before the North Carolina Section meeting, November 15, 1923.

[2] President, Virginia Machinery and Well Co., Richmond, Va.

sand is likely to be encountered on top of the rock which it may be difficult to eliminate from the well by casing. Furthermore, the drainage from contaminating influences more easily penetrate a well so located.

Generally speaking a hillside site is preferable so as to bisect and intersect the crevices and faults which, more often than not, will lie at an angle to the surface of 20° to 60°. These crevices frequently bisect each other, so that water may come into the well from a crevice which bisects the one penetrated by the drill.

What I have said applies more particularly to the Piedmont Section and to the crystalline rocks than to the Mountain or Coastal Plain Sections of the State.

There is a fairly well defined section of North Carolina quite wide in area and extending practically across the State and into South Carolina where shale and slate formations predominate. In this section and in these formations particularly, it is difficult to obtain large yields of water from drilled wells, and the deeper the well the less likely it is to prove satisfactory, certainly if in a formation partaking of slate. The axis of this line might be said to run diagonally through the State from Roxboro on the North, through Durham, Sanford, Marshville and on into South Carolina through Chesterfield.

West of this line there is a stratum of very hard rock which lies more like a pocket in the center of the State, taking in Randleman, Asheboro, Ramseur, Albemarle and Troy, in which it is also quite unlikely that large yields may be expected. The country in which this rock occurs is noted for the quartz boulders which lie on the surface, in many places so thick as to make the land worthless agriculturally.

In the Coastal Plain, which is divided from the Piedmont by the Fall line which runs through the State approximately from Weldon to Selma, then bending Southwest to Hamlet, wells can be counted on with much more certainty to furnish a good supply. In many parts of this section they flow. In sand wells the problem is to determine the best sand strata to develop and to use strainers of such mesh or orifice of inlet as to let in the water and to keep out the sand; not to have the strainer so fine as to clog the well nor yet so coarse as to permit fine sand to flow constantly into the well; and in the case of a deep well pump, choke up the valves, cut out the leathers and cylinder or working barrel. Generally speaking

the coarser the strainer the better it is for permanency of yield and freedom from operating troubles. It is almost invariably true that a brass strainer of special construction is more durable than a pipe strainer.

The pumping of a sand well can be done more satisfactorily with air as a rule than with a deep well pump, as there are no working parts in the well with an air lift. It is also true that air lift pumping is notoriously inefficient in economy.

When it is determined to pump with air, it is often not necessary to use a strainer in finishing the well, particularly if the strata be coarse and the flow or yield strong, as the air soon exhausts the fine sand, leaving the coarse sand and gravel to serve as a filter bed.

So much for the practice of locating a well.

With regard to the mechanical features of drilling and developing a well I would say

First, get a good well driller.

Second, use as few restrictions as your conscience will permit in hedging him about in your specifications, consult him freely as to his opinion and use his advice or not as you like.

In a rock well I would suggest that the well be specified at least one size larger in diameter than you expect the finished size to be, as it may not be practicable to drill the well the same diameter from start to finish. Loose rock may fall in which interferes with the drilling and endangers the operation so that it is not safe for the driller to proceed unless it is cased out. Running sand may be encountered which it is necessary or desirable to cut out. An undesirable water may have to be cased off. Ordinarily a well starting 10 inches in diameter is large enough and this may finish 10 or in most cases 8 inches which is sufficiently large in diameter to permit of the use of a deep well pump of 120 g.p.m. capacity.

The well should be lined to the rock with full weight genuine wrought iron drive pipe, with recessed drive couplings. This is more for the protection of the owner than the driller, as it is generally conceded that wrought iron lasts far longer than steel, particularly when exposed to the chemical action of some soils, and the oxidation due to water. A wrought forged steel drive shoe should be used on the bottom end of the pipe to facilitate driving the pipe and to protect the end of it so that it will seat squarely on or in the rock and eliminate surface water. As rock is a little soft usually and disintegrated on top or where it joins with the clay this shoe and pipe can usually be driven a short distance into the rock.

Should any of the contingencies arise necessitating reducing the bore of the well, it should be telescoped or relined from the surface of the ground to the point of reduction of diameter with the same character of pipe and shoe with which it is lined to the rock.

Above all, the well should be drilled straight so as to permit the use of the largest size pipe and cylinder that the yield of the well will afford.

Generally speaking, very deep wells are not profitable in yield of water, around 500 or 600 feet usually being the point beyond which it is not desirable to go.

Adequate testing of the well is most important. A twenty-four-hour continuous test is as short a time as it is safe to determine the permanency of the yield. Longer tests are desirable.

As the pumping head, i.e., the point to which the water drops and remains constant while the well is being pumped, is usually within 200 feet from the surface, it is ordinarily not necessary to have the test cylinder placed lower than this. If the pump takes air with the cylinder placed at this depth, the well usually has a poor yield. A test of approximately 100 g.p.m. is within the capacity of the equipment of a well equipped driller. Testing with air in a sand well is desirable and the good driller is equipped to do it.

In a sand well, it is frequently necessary to sand bucket or sand pump the water bearing sand for quite a while to determine whether the sand is a good yielder of water and coarse enough to develop satisfactorily. Provision should be made for this in the specifications.

There are many ways to pump a deep well. Of course a flowing well delivering water directly into a reservoir is ideal, but is seldom found. In fact, there are few wells which do not require the use of an air lift or deep well cylinder or a moving element.

It is always well to make the bore of sufficient size to permit the use of a working barrel of the capacity required, although, if it is intended to use air permanently, the well can be considerably smaller than if some other type of pump be used.

From a 6-inch well as much as 200 g.p.m. may be pumped with air, while the same well will admit a working barrel which at the maximum will not deliver over 75 g.p.m.

A 12-inch or larger well will permit the use of a deep well centrifugal pump with a capacity of 500 g.p.m., provided the water does not drop too low in the well while pumping.

An impeller type of pump may be used in wells as small as 6-inch and these have a capacity of 100 g.p.m. and up. This type of pump is quite expensive and not very efficient, nor are they tried and true as are the air lift, plunger pump or deep well centrifugal. The most efficient deep well pump is the double plunger, double rod continuous flow pump, with which the column of water is kept continuously in motion from start to finish. A pump of this type under favorable conditions will operate with as high as 80 per cent mechanical efficiency. Because of its design the frequent breaking of rods, the jar and vibration incident to the single acting, single plunger pump, will be avoided. A double acting cylinder with guided rod is fairly efficient and more satisfactory than a single acting cylinder, though the water must come to a stop at the end of each stroke with this pump.

Chain drives for direct connected pumps are equivalent to motor drive direct connected and are more flexible, combining the flexibility of belt drive with the sureness and positiveness of gear drive. Slow speeds are preferable for plunger pumps with motor speeds not exceeding 1200 r.p.m. Slip ring motors are better than squirrel cage.

Air chambers on the discharge line are essential, preferably of large size. Check valves with rubber valves, spring loaded, promote quietness of operation and prevent leakage back into the well.

Periodically the rods, pipe and cylinder of a plunger pump should be examined to see that all threads and joints are tight to avoid any part dropping off in the well.

No deep well pump should be permitted to take air. If this condition develops the speed should be changed or the cylinder dropped lower in the well.

A convenient arrangement for pulling the rods of a deep well pump is a winch or cat head attached to the pinion shaft. This works out nicely with motor drive.

THE RELATION OF HARDNESS IN WATER SUPPLY TO PUBLIC HEALTH[1]

By E. Sherman Chase[2]

One of the questions water works men are frequently called upon to answer is "How does the hardness of a drinking water affect health?" The answer to this question may be sought by means of physiological and medical research or by a study of mortality statistics. The following paper deals with the latter line of inquiry and consists of a comparison of statistical data relative to mortality from certain selected diseases amongst populations supplied with "soft" water with similar data for populations supplied with "hard" water.

POPULATIONS CONSIDERED

The populations supplied with soft water, which are here considered, are the urban populations of the two New England states of Massachusetts and Connecticut. The hardness of the water supplies of the cities of these states will range from approximately 10 to 30 parts per million (the Wachusett supply of the Boston Metropolitan District has a hardness of about 10).

The populations supplied with hard water which are considered are the urban populations of the middle west states of Ohio and Michigan. The hardness of the water supplies of these states will range from approximately 100 to 250 parts per million, about 10 times that of the waters of the two New England states.

The populations of the urban communities of these four states are reasonably comparable. The principal cities are industrial centers and probably contain approximately the same proportions of foreign populations. The age distribution is also very nearly the same in all cases with a slightly larger proportion of children in the two western states. The age distribution is shown by table 1.

[1] Presented before the Chemical and Bacteriological Section, Detroit Convention, May 24, 1923.

[2] Sanitary Engineer, Metcalf and Eddy, Boston, Mass.

This table shows that, in the case of the age groups 45 and above, the proportions in the four states are very nearly the same. This is a particularly important consideration in dealing with the particular diseases which have been selected for comparison, as these diseases occur mainly in the higher age groups.

TABLE 1

Distribution of urban population by age groups (United States Census 1910)

AGES	MASSACHUSETTS	CONNECTICUT	OHIO	MICHIGAN
years				
Under 5	9.8	10.1	10.1	10.6
5- 9	8.8	9.1	9.2	9.8
10–14	8.5	8.5	8.9	9.2
15–19	8.8	9.1	9.4	9.5
20–24	9.7	9.7	9.5	9.4
25–29	9.3	9.1	9.0	8.6
30–34	8.3	8.1	7.9	7.5
35–44	14.9	14.4	13.7	12.9
45–54	10.5	10.2	10.2	10.2
55–64	6.2	6.2	6.6	6.6
65 and over	5.2	5.3	5.5	5.6

DISEASES CONSIDERED

From the International Classification of Causes of Death as given in the Mortality Statistics of the United States Census, some six diseases have been selected as ones which might conceivably be affected by the hardness or the softness of water supplies. These diseases are: diseases of the arteries, atheroma, aneurism, etc; biliary calculi; acute nephritis; Bright's disease; calculi of the urinary passages; and diseases of the bladder. Whether there is any physiological evidence to show that these diseases are affected by the degree of hardness of drinking water is not within the scope of this paper. It may be stated in passing, however, that published opinions in this matter are somewhat conflicting. It is believed, however, that the six diseases selected cover a sufficiently inclusive range for the purposes of this study.

COMPARISON OF DEATH RATES

Table 2 gives the deaths for diseases of the arteries, per 100,000 population, for the four urban populations considered and for the

three years 1915 to 1917. The years selected are such that the disturbing effect of the war period with respect to age distribution and other abnormal conditions is avoided. The rates are taken from the annual mortality reports of the Federal Census.

This table indicates that, in the case of diseases of the arteries, the advantage, if any, lies with the populations supplied with hard water. It must be noted, however, that the Connecticut cities have the lowest death rate of this disease of any of the four urban popula-

TABLE 2

Diseases of the arteries (Int. No. 81) deaths per 100,000 population (urban)

DATE	SOFT WATER		HARD WATER	
	Massachusetts	Connecticut	Ohio	Michigan
1915	36.7	22.7	25.2	25.8
1916	41.0	27.0	27.3	33.4
1917	46.9	28.7	28.3	32.2
Average.....	41.5	26.1	26.9	30.5
Group average.	33.8		28.7	

TABLE 3

Biliary calculi (Int. No. 114) deaths per 100,000 population (urban)

DATE	SOFT WATER		HARD WATER	
	Massachusetts	Connecticut	Ohio	Michigan
1915	4.2	4.4	5.2	4.3
1916	4.3	3.4	4.9	4.4
1917	4.6	3.5	5.3	4.0
Average.....	4.4	3.8	5.1	4.2
Group average.	4.1		4.7	

tions and it does not appear that the evidence warrants attributing any material effect of water supply hardness upon diseases of the arteries.

Table 3 is similar to table 2, but deals with deaths from biliary calculi.

From this table it would appear that a slight advantage with respect to deaths from biliary calculi rests with populations supplied by soft water. It should be noted, however, that the Massachusetts

rates are higher than those for Michigan. It accordingly seems doubtful whether these figures indicate any real or material advantage, as far as deaths from biliary calculi are concerned.

Table 4 is similar to the preceding, but with acute nephritis as the cause of death considered.

Here again there appears to be a slight advantage for the soft waters, but it will be noted that Connecticut has a higher rate from this cause than either of the hard water states. The low rate in

TABLE 4

Acute nephritis (Int. No. 119) deaths per 100,000 population (urban)

DATE	SOFT WATER		HARD WATER	
	Massachusetts	Connecticut	Ohio	Michigan
1915	7.0	10.8	11.6	9.8
1916	6.5	13.8	10.2	9.4
1917	6.2	13.6	10.2	10.1
Average.....	6.6	12.7	10.7	9.8
Group average.	9.65		10.25	

TABLE 5

Brights disease (Int. No. 120) deaths per 100,000 population (urban)

DATE	SOFT WATER		HARD WATER	
	Massachusetts	Connecticut	Ohio	Michigan
1915	84.5	106.7	87.0	74.9
1916	88.8	113.6	88.2	75.5
1917	87.6	115.9	91.0	79.3
Average.....	87.0	112.1	88.7	76.8
Group average.	99.5		82.7	

Massachusetts is responsible for the low average rate for the soft water populations.

Table 5 is also similar to the preceding tables, but comparing the death rate for Bright's disease.

This table indicates an advantage for the hard water districts, in Bright's disease, due mainly to the materially higher rate for this disease in the cities of Connecticut than in the cities of the other states. The high death rates from kidney disease (nephritis and

Bright's disease) in Connecticut are probably the result of some local condition which is not readily apparent. It will be noted that the Massachusetts rate, while higher than the Michigan rate, is almost the same as the rate in Ohio. From the evidence presented in this table, however, it cannot be stated with any degree of positiveness that the hardness or softness of water supplies has any clearly defined effect upon the death rate from Bright's disease.

TABLE 6

Calculi of the urinary passages (Int. No. 123) deaths per 100,000 population (urban)

DATE	SOFT WATER		HARD WATER	
	Massachusetts	Connecticut	Ohio	Michigan
1915	1.2	0.7	0.8	1.1
1916	0.8	0.8	1.0	0.6
1917	0.8	0.2	0.9	0.9
Average.....	0.93	0.57	0.90	0.87
Group average.	0.75		0.88	

TABLE 7

Diseases of the bladder (Int. No. 124) deaths per 100,000 population (urban)

DATE	SOFT WATER		HARD WATER	
	Massachusetts	Connecticut	Ohio	Michigan
1915	4.3	2.1	1.3	1.9
1916	1.0	1.2	1.4	2.3
1917	1.3	1.0	1.0	1.9
Average.....	1.20	1.43	1.23	2.03
Group average.	1.32		1.63	

A comparison of the death rates from calculi of the urinary passages, one of the diseases which is frequently referred to as being aggravated by hard water is given in table 6.

The figures given do not indicate that this disease is materially affected by hard water. It is true that the average death rate from this disease during the three years studied is lower for Massachusetts and Connecticut than for Ohio and Michigan, but the lower average for the soft water states results from the low death rate in Con-

necticut for the year 1917. Further evidence would be required to demonstrate conclusively that hard water increases the number of deaths from calculi of the urinary passages.

Table 7 gives a comparison of the death rates from diseases of the bladder.

While this table shows a somewhat lower average death rate from diseases of the bladder in Massachusetts and Connecticut than in Ohio and Michigan, the difference is slight. Furthermore, Connecticut has a higher rate than Ohio, and Ohio and Massachusetts have almost the same rates, Michigan rates being higher than any of the other three. This table, therefore, cannot be considered as establishing any clear connection between the hardness of water supplies and the death rates from bladder diseases.

CONCLUSIONS

From this brief and rather limited study of mortality rates, the tentative conclusion may be reached that the statistical evidence indicates no relation between hardness in drinking water and deaths from diseases of the arteries, kidneys, or bladder. It would be of interest, however, to extend this inquiry by making a more detailed study of mortality in specific municipalities with water supplies of various degrees of hardness and with various proportions of permanent and temporary hardness. In the case of cities using softened water supplies, it would also be of interest to compare mortality rates before and after the softening plants were put into service.

DISCUSSION

LOUIS L. TRIBUS:[3] Probably a large number of white Americans, and many inhabitants of the more enlightened European lands, have grown up with the idea that the quality of waters for drinking purposes has much to do with individuals and public health. There is no question that from bacteriological standpoints this is the case, and that there may be some effect from those having very considerable mineral content.

We are viewing the case solely from the human consumption side, not from use of soap, deposition in boilers, piping, etc.

There has been a very general impression, backed extensively by physicians, that "hard" waters are trying to the kidneys, may

[3] With Tribus and Massa, Consulting Engineers, New York, N. Y.

produce gall stones, and some go so far even as to suggest goitre as a consequent evil.

The usual "hard" elements of hard waters are such minerals as are not deposited at temperatures below the boiling point, do not readily oxidize, and are not generally soluble in the juices of the digestive system, so have every good reason for passing out of the body in practically the same chemical status as at time of entering.

Various therapeutic springs are much sought for and some habitues credit them with great cures. We would not deny that some human systems are helped by the alkali ingredients of some waters which may attract their excess of acids, though we believe that rest and imagination have much to do with the case, and far more the extensive and unusual water flushing that the water cure visitor indulges in.

A few months ago a well-known medical writer was sought for advice through a newspaper. Let us quote the letter and the reply:

Mrs. B. F.—Several years ago an examining physician for an insurance company advised me to drink only soft spring water, as I have a tendency to nephritis, but I have not done so for more than three years. The water in my home is exceedingly hard and I have had two attacks of acute kidney disease during the year I have lived here.

The Answer

Water is hard or soft according as it contains more or less foreign ingredients in solution, particularly mineral matter.

The softest water is distilled water or pure rain water but the latter is seldom obtainable, for it is almost sure to dissolve some kind of foreign material from the moment it reaches the earth.

If the water you are drinking is very hard—that is, contains much mineral—and your kidney disease, whether inflammation or formation of stone, seems traceable to this source, I would advise you to use only distilled water.

The advice was good, well qualified by "ifs," but seemed worthy of further thought.

A rather lengthy letter of inquiry was sent to the Editor-Physician, as to whether he had any *authentic* information from his practice, or that of others, where the drinking of hard water had been known to produce any intestinal disability.

The reply was that, in his large practice, it had become common knowledge that the drinking of hard waters was undesirable; but he gave no conclusive evidence.

The writer had given him some data upon which to draw out comment, but failed to elicit anything definite; the data may perhaps be repeated here in part so as to bring out some discussion:

As waters go, mineral contents, not removable by filtration, ranging from 50 to 300, or more, parts per million, class as "hard."

Some time ago in our water supply practice certain ones in the particular community at issue insisted that "hardness" in the local supply was the chief cause of gall-stones and also injuriously affected the kidneys. We had had personal experience with water supplies in various parts of the country and had not encountered any special trouble chargeable to hardness; but we took up the question locally, and with the Departments of Health of Massachusetts, New York, New Jersey, Pennsylvania and Kansas, covering thus a wide range of potable waters, and in every instance, after quite full study, reply came that, no instances were known to the Departments where "hardness" had been reported as the cause of any intestinal or organic disability.

Locally we found no proof, only some claims which were more likely to have been imaginative than real. Have any of our water friends anything to add? Perhaps something definite can be presented as to relationship of hard water to rheumatism.

TASTE AND ODOR IN CHLORINATED WATER[1]

By R. M. Warren[2] and Edward Bartow[2]

Taste and odors in water arise from two main conditions created by modern factory practice and habits of domestic life. The increased amount of factory waste plus city sewage on the one hand and a demand for a higher purity and agreeableness on the other often create an acute situation.

Taste and odor are intangibles, for their origin and nature are frequently hard to ascertain and measure. What is disagreeable to one person may not be to another. Therefore, a classification as to quality and quantity is almost impossible.

The system of measurement which is used in this work is described in the Standard Methods of Water Analysis of the American Public Health Association.

Numbers varying from 0 to 5 are assigned to odors of varying intensity. The numbers indicate roughly whether the odor is noticeable to an inexperienced person; to an experienced person; whether it is unpalatable or undrinkable.

Taste and odors have been attributed to bleaching powder and chlorine used in water treatment.

Chlorine was known to be germicidal as far back as 1881, when Koch used bleaching powder for germicidal purposes, but it was not until 1908 that calcium hypochlorite was used for municipal water works. At the Bubbly Creek plant at the stock yards in Chicago and at the Boonton reservoir of Jersey City, it was first found to be of value in water treatment and its use has grown rapidly.

Hypochlorite is troublesome due to its bulk and the loss of chlorine during storage. In 1911 liquid chlorine began to be used. Now the water used by hundreds of towns, including New York using 550 million gallons of water per day and Chicago using 700 million gallons, is treated with liquid chlorine.

[1] Presented before the Iowa Section meeting, November 1, 1922.

[2] Department of Chemistry, University of Iowa, Iowa City, Iowa.

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[2] Department of Chemistry, University of Iowa, Iowa City, Iowa.

Since the use of chlorine was started there have been several notable cases of taste and odor. In 1910 Milwaukee first met with trouble from the United States Phenol Plant at Carrollville and from the adjacent gas and coke companies. This trouble lasted over a period of several years and ended only when the phenol plant was closed and the local gas and coke companies discharged their waste at a point distant from the city intake pipes. There has been similar trouble in towns along the Monongahela river in Pennsylvania.

In some cases steps have been taken to remove taste and odor, while in others steps have been taken to prevent them.

Some of the methods used to remove taste and odor are:

1. Powdered coke and charcoal in contact with the water followed by filtration.
2. Hydrogen peroxide and several per salts, e.g., per-carbonates.
3. Sulphur dioxide which is recommended and used by Sir Alexander Houston.
4. Permanganates.

The methods used to prevent taste and odor are:

1. Aeration and storage before chlorination.
2. Care of watersheds.
3. Control of the amount of chlorine.

A symposium held in 1921 by *Engineering News-Record* shows opinions which are held by American operators concerning the use of liquid chlorine. The conclusions drawn by the editor relating to taste and odor are as follows:

1. The variation as to amount of chlorine, time of contact, etc., is due to different characteristics of suspended and dissolved foreign matter in water.
2. Substances other than water react with chlorine to give disagreeable compounds. Taste is not of chlorine or of HOCL and HCl as expressed in the equation:

$$Cl_2 + H_2O \rightleftarrows HCl + HOCL.$$

Water is sufficiently alkaline to prevent acid formation in free state.

3. Cold water troubles are due to other factors than chlorine.
4. No limit can be placed on amount of residual chlorine which will produce taste.
5. Well water with 0.01 p.p.m. may taste. Surface water with 0.8 p.p.m. may not taste.
6. After certain limits up to 600 to 1000 units per cubic centimeter an algae infested water requires more chlorine.
7. Chlorination has come to stay in water treatment.

It can be seen from the reports mentioned above that taste and odor arise from many different conditions. Turbidity has been found to affect the amount of chlorine necessary and, therefore, the taste and odor developed. Temperature also affects the amount of chlorine that can be added. (In using hypochlorite, six pounds per million gallons could be used during fall and winter.) Organic matter plays a large part, its nature and amount being a determining factor.

It is the opinion of some investigators and operators that taste and odor are due principally to the excess of chlorine above that needed for sterilization. Wolman and Enslow and Sperry and Billings are the strongest advocates of this relationship between chlorination and taste and odor developed. So far nothing definite has been proven concerning the variability of taste and odor with the amount of chlorine present, with oxygen consumed or with chlorine absorbed in a given time.

The present work was carried out in search of some relation between taste and odor and chlorine, to see what effect certain treatment, such as aeration and standing, would have on the taste and odor developed from chlorine.

Waters from different sources differ in many ways and the results of chlorination naturally vary greatly. Waters of different character were used in these experiments.

The first experiment was made in an attempt to determine the amount of chlorine required to give a taste in a water of highest purity, i.e., distilled water.

This amount was determined by Bartow and Van Brunt to be 3 p.p.m. in distilled water, but the following data from the writer's own experiment are presented further to justify this amount in the present work.

SAMPLE	CHLORINE	TASTE	ODOR
	p.p.m.		
1	1.7	0	1
2	3.4	3	3
3	6.8	4	4
4	13.6	5	5

This experiment was carried out in beakers containing varying amounts of applied chlorine with the result that 3 p.p.m. had to be applied to give a taste which would be disagreeable.

An amount less than this was chosen for subsequent experiments, so that taste and odor would be due to action on impurities present rather than chlorine.

An experiment carried out with river water containing varying amounts of organic matter, such as algae, shows a direct ratio between the amount of impurities present and the taste and odor developed.

To make the relation clear the table below is given to correlate the parts per million of chlorine absorbed and resulting taste and odor. All observations were made on the same samples.

JAR	OXYGEN CONSUMED	TEN MINUTES			THIRTY MINUTES			SIXTY MINUTES		
		Chlorine absorbed	Taste	Odor	Chlorine absorbed	Taste	Odor	Chlorine absorbed	Taste	Odor
1	20.8	1.8	5	5	1.9	5	5	2.0	5	5
2	9.9	1.7	5	5	1.8	5	5	1.9	5	5
3	9.5	1.6	5	5	1.8	5	5	1.8		
4	5.5	1.1	3	4	1.7	3	4	(2.0)	2	3
5	3.8	0.9	4	5	1.3	2	1	1.7	2	3
6	0.1	0.6	4	4	0.9	3	3	0.9	3	4

The same experiment shows that, measured by oxygen consumed, chlorine absorbed also varies with organic matter present. This would indicate that taste and odor vary with chlorine consumed rather than residual chlorine.

RIVER WATER, EFFECT OF AERATION

The aeration experiment is made further to associate the phenomenon of taste and odor with amount of chlorine present and the amount of oxidized materials present. The amount of chlorine absorbed was the measure of oxidized material in the previous experiment. No means were used to measure the oxidized material, it being assumed that the more organic matter present in the beginning the greater amount of chlorine absorbed.

When excess chlorine was added compressed air was used. All six bottles were connected to one bottle containing a stopper with seven holes, one hole for air inlet and the other six for outlets to the six bottles.

The following table shows the relationship. The same jars and material of the previous experiment were used, after the end of the sixty minute absorption period.

JAR	AERATED ONE-HALF HOUR			STANDING CLOSED FIVE HOURS		
	Cl_2 residual	Taste	Odor	Cl_2 residual	Taste	Odor
1	0	4	2	0	5	5
2	1	4	1	0	4	4
3	1	3	1	0	3	3
4	(0)	2	1	0	1	2
5	0.3	2	1	0	2	1
6	0.3	1	2	0	2	2

The conclusions may be summarized as follows:

1. Aeration removes some taste and much odor.
2. Presence of chlorine increases odor, but is not essential to it.
3. Taste varies as the amount of oxidized material present, while odor becomes constant after treatment.
4. On standing, even more oxidation takes place and, with no escape, the bad taste and odor accumulates.
5. Standing in open or aeration should be good treatment for water after chlorination.

STUDIES MADE ON GAS HOUSE WASTE

Among the numerous industrial wastes giving trouble in water purification, gas house waste take first place.

The first thing one would want to know is how much gas waste could be in water with no taste and odor before chlorination. The following experiment was made to answer this question concerning the water gas waste from the local plant. This would be about typical of any gas waste going into streams and rivers. The waste that was used in this experiment is called "drip water." It is the water which condenses in the storage tank and collects in a tank just outside. The oily material settles to the top and the suspended matter to the bottom. The clear brown liquid in the middle was siphoned and used.

Five hundred cubic centimeters of distilled water containing varying amounts of waste were observed as follows:

PARTS PER MILLION	PER CENT	TASTE	ODOR
80	0.008	Slight	Marked
40	0.004	None	Slight
20	0.002	None	None

Water would have to contain around 80 p.p.m. or 0.008 per cent to be disagreeable, if clarified and used unchlorinated.

Five hundred cubic centimeters of distilled water treated with varying amounts of gas waste and 1 p.p.m. of chlorine were used for observations to determine how much of the water gas waste would give taste and odor. One part per million of chlorine with one part per million of waste gives taste.

As in the case of river water, the odor is found to decrease faster than taste, both by standing and by decreasing the amount of waste.

CONCLUSIONS

1. Chlorinated water may have taste other than that given by excess chlorine.

2. Taste and odor may be developed by other oxidizing agents than chlorine and generally increases with chlorine absorbed.

3. Aeration may increase taste by further oxidation rather than remove it.

4. Oxygen consumed method of control good only where taste and odor are due only to excess chlorine.

5. Water should have access to air to give escape to odors developed.

6. For any given water there is an oxygen consumed value above which chlorine will give taste and odor. When this limit is reached, some method of oxidation should be used before sedimentation and filtration, so as to give opportunity for dissipation of taste and odor during treatment and before final chlorination.

7. Colorimetric method not accurate, if water contains any appreciable amount of phenol or cresol.

OPTIMUM HYDROGEN ION CONCENTRATIONS FOR COAGULATION OF VARIOUS WATERS[1]

By G. F. Catlett[2]

At a conference of engineers and filter plant superintendents of the Southeastern States, held at Atlanta in July, 1922, Mr. E. J. Theriault described comprehensively results obtained by the United States Public Health Service in an exhaustive laboratory study of the value of hydrogen ion concentration in the control of coagulation at water purification plants. This study was made for the most part on artificially prepared turbidities and added buffers, although some results were obtained on natural Potomac river water. As described by Mr. Theriault the indications were that this determination would be of the greatest value to the filter plant man in controlling his dosage, so as to secure economy of chemicals, efficiency in filtration, the elimination of coagulant in filter effluent and possibly the prevention of the corrosive action of certain low alkalinity filter plant effluents.

As suggested by Mr. Theriault this laboratory research had reached the stage, when the next logical procedure was the application of the same line of investigation to the actual conditions found in various municipal water plants. With this idea in mind, a series of tests were undertaken by the North Carolina State Department of Health, on the various public water supplies in that State. As the types of water supply found in this State vary from the highly colored swamp waters of the Atlantic Seaboard to the clear mountain supplies of the Blue Ridge, it was felt that conditions were favorable for such studies. The important questions to be determined were:

1. What constitutes the optimum hydrogen ion concentration in various waters?

2. Does the holding of the water treatment to such values result in improved efficiency and economy in plant results and is it practicable to secure such control?

[1] Presented before the Chemical and Bacteriological Section, Detroit Convention, May 25, 1923.

[2] Principal Assistant Engineer, State Board of Health, Raleigh, N. C.

3. Can a dependable method be devised for determining hydrogen ion concentration that may be used successfully by the average plant operator.

METHOD OF MAKING THE DETERMINATION

The determination of hydrogen ion concentration by electrical methods was not considered, as the apparatus is too expensive for the small water plant and the technique too elaborate for the average operator. For the large plants it is entirely suitable and, of course, furnishes the most reliable figures. It is also useful for standardizing the color methods.

In order to arrive at a suitable colorimetric technique, tests were started at the Wilmington, N. C., plant. Close coöperation and assistance was furnished by Mr. Geo. D. Norcom, the superintendent of filtration. The standards supplied by the LaMotte Chemical Company were first tried, but were found unsatisfactory as regards permanence, the methyl red standards especially spoiling very quickly. Pure chemicals were next secured and buffer solutions made, from which standards could be made up as needed. Very good results were obtained in this way, but only a well trained chemist with a good laboratory could be relied upon to make such standards.

In *The Determination of Hydrogen Ion Concentration* by Dr. W. M. Clark a color chart is shown reproducing the colors of the various standards, made in accordance with the method of Clark and Lubs. It was found that using these charts in place of the tube standards gave satisfactory results that compared very favorably with tubes made from standard buffer solutions and with fresh LaMotte Chemical Company standards. In order to check possible variation due to the personal equation, determinations were made using tube standards and color chart, and by several observers, some of whom had had no previous experience in this class of work. The results showed close agreement and sufficient accuracy to warrant using charts for the purpose of water treatment control.

In order to carry out this technique it is only necessary to have one of the charts, which are sold separately from book, some indicator solutions, tubes graduated to hold 10 cc., a 1 cc. pipette graduated in tenths, and a bottle of distilled water. The indicator solutions are made from the dry powder purchased from LaMotte Chemical Company and in accordance with Clark's method, except that after rubbing up the dry indicator in a mortar with the

specified quantities of N/20 soda, the final dilution was made with 85 per cent ethyl alcohol instead of distilled water. These solutions are 20 times too strong in case of methyl red and 10 times too strong in the case of the other indicators.

It is necessary to make these concentrations in order to secure keeping qualities, and for making the tests they must be diluted with distilled water. The concentrated alcoholic solutions seem to keep almost indefinitely, a set having been used over a period of eight months with no deterioration. All of the tests given in table 1 were made by this method, with sufficient checking by tube standards to insure the uniformity of results. It is a significant fact that tests made on the same water at beginning of the eight months showed the same results as at the end of this time, although the same stock indicator solutions were used for entire period. The colors on the charts do not seem to fade appreciably and they are cheap enough to make their replacement no obstacle.

This technique seems to meet the needs of the small plant operator, and as described forms a much simpler test than the determination of alkalinity by titration with acid.

DETERMINATION OF OPTIMA

Clark and Theriault (Public Health Reports February 2, 1923) state that as a result of their investigation: "When other possible factors are left out of consideration, optimum conditions for floc formation will be found with a narrow zone of pH centered for dilute solutions at pH 5.5." J. R. Baylis (*Proc. American Society Civil Engineers*, December, 1921) gives an optimum for Baltimore city water at 6.5. Wagner and Enslow (*Journal American Water Works Association*, May, 1922) give an optimum zone for "non organic" waters 6.5 to 7.0 and for "organic waters" a zone as low as 5.7 and never above 6.5. These figures indicate quite a variation in optima.

Tables 1, 2 and 3 give optima determined on a number of North Carolina waters. Those in table 1 check the figure set by Clark and Theriault. These waters are practically all located in the east central part of the State and contain a certain amount of color as well as turbidity. Table 2 shows some waters located in the south central part of the State with optima consistent with those found by Baylis, and Wagner and Enslow. These waters are more or less turbid with practically no color.

Table 3 gives the figures on the highly colored clear waters. The water used at Hamlet and Lumberton, with comparatively low colors, give optima around 5.5, while the three supplies at Wilming-

TABLE 1

Waters with optimum 5.5

NUMBER OF TEST	TOWN	NATURE OF RAW WATER	ALKALINITY	COLOR	TURBIDITY	pH RAW WATER	OPTIMUM pH
1	Rocky Mount	Tar River	23	20	50	6.4	5.6
2	Rocky Mount	Tar River	21	10	350	6.4	5.6
3	Rocky Mount	Tar River	21	40	80	6.4	5.6
4	Tarboro	Tar River	18	20	50	6.4	5.6
5	Tarboro	Tar River	16	20	300	6.4	5.6
6	Greenville	Tar River	17	30	50	6.4	5.6
7	Greenville	Tar River	19	20	300	6.4	5.6
8	Raleigh	Impounded Creek	17	20	40	6.4	5.6
9	Hickory	Creek	8	10	60	6.2	5.6
10	Salisbury	Yadkin River	18	10	350	6.4	5.6
11	Winston-Salem	Impounded Creek	21	20	100	6.8	5.6
12	Henderson	Impounded Creek	7	0	50	6.4	5.8
13	Wilson	Creek	14	30	40	6.4	5.6
14	Wilmington	Cape Fear River	9	80	200	6.3	4.8
15	Wilmington	Cape Fear River	7	80	20	6.3	5.6
16	Wilmington	Cape Fear River	8	40	150	6.6	5.6
17	Washington	Creek	19	60	60	6.4	5.6
18	Goldsboro	River	7	60	150	6.8	5.6

TABLE 2

High optimum turbid waters

NUMBER OF TEST	TOWN	NATURE OF RAW WATER	ALKALINITY	COLOR	TURBIDITY	pH RAW WATER	OPTIMUM pH
19	Durham	Impounded Creek	21	0	80	6.8	6.6
20	Gastonia	Impounded Creek	21	0	40	7.6	7.0
21	Gastonia	Impounded Creek	20	0	300	7.0	6.6
22	Charlotte	Catawba River	23	0	200	6.8	7.6
23	Concord	Creek	39	0	80	6.6	6.6
24	Wadesboro	Creek	11	0	60	6.6	6.4
25	Lexington	Creek	40	0	60	7.2	7.0

TABLE 3

High colored clear waters

NUMBER OF TEST	TOWN	NATURE OF RAW WATER	ALKALINITY	COLOR	TURBIDITY	pH RAW WATER	OPTIMUM pH
26	Lumberton	Lumber River	6	150	30	6.2	6.3
27	Lumberton	Lumber River	0	150	30	5.4	5.2
28	Hamlet	Impounded Creek	7	70	0	6.4	5.7
29	Wilmington	Northeast River	6	250	30	5.9	4.3
30	Wilmington	Northeast River	9	150	20	6.3	5.0
31	Elizabeth City	Knobs Creek	8	200	20	6.4	4.5
32	Hertford	Perquimans River		500	0	5.6	4.8

ton (northeast river), Hertford and Elizabeth City, with an excessive color, show much lower optima. The first two are located in interior of the State, while the latter three are on the coast.

TABLE 4

NUMBER OF TEST	ALUM	ALKALI	pH	FLOC
	g.p.g.	*p.p.m.*		
1	0.5	0	6.2	None
2	1.0	0	6.0	Poor
3	1.5	0	5.6	Excellent (optimum)
4	2.0	0	5.2	Slow
5	2.5	0	5.0	None

TABLE 5

NUMBER OF TEST	ALUM	ALKALI	pH	FLOC
	g.p.g.	*p.p.m.*		
1	3.5	10	4.8	None
2	3.5	14	5.2	Poor
3	3.5	18	5.4	Excellent
4	3.5	22	5.6	Excellent
5	3.5	28	5.8	Good (slow)
6	3.5	30	6.0	Good (slow)
7	3.5	32	6.0	Poor (very slow)
8	3.5	36	6.4	Very Poor
9	2.0	6	5.2	Poor
10	2.0	8	5.4	Fair
11	2.0	10	5.6	Fair (optimum 2 grains alum)
12	2.0	12	5.7	Fair
13	2.0	14	5.8	Fair
14	2.5	8	5.0	Poor
15	2.5	10	5.2	Poor
16	2.5	12	5.4	Poor
17	2.5	14	5.6	Good
18	2.5	16	5.7	Good
19	2.5	18	5.7	Good
20	2.5	20	5.8	Slow
21	2.5	24	6.2	Slow, fair
22	2.5	28	6.4	Fair, smoky
23	2.5	32	6.6	Fair, smoky
24	2.5	36	6.8	Poor
25	2.5	40	6.8	Poor

The method used for determining optima on these waters, consisted in using the ordinary "jar test" and applying the results

obtained with this to the plant itself. A series of 1 liter jars were used and alum, soda and lime solutions prepared so that each cubic centimeter of alum solution put in a jar of raw water would be the equivalent of $\frac{1}{2}$ grain per gallon, and each cubic centimeter of alkali solution in the same way was equivalent to $\frac{1}{8}$ grain per gallon. In this way any combination of chemicals could be used. The pH was then determined on each jar test, and the jar furnishing a floc most quickly was considered the optimum. In this connection it may be noted that the observation of Clark and Theriault that the quickest forming floc is always eventually the best floc was borne out in these tests.

TABLE 6

NUMBER OF TEST	ALUM	ALKALI	pH	FLOC
	g.p.g.	*p.p.m.*		
1	2.0	0	5.8	None
2	2.0	6	6.0	None
3	2.0	12	6.2	None
4	2.0	16	6.3	Poor
5	2.0	20	6.4	Poor
6	2.0	30	6.6	Excellent
7	1.0	15	6.6	Excellent
8	1.0	10	6.4	Poor

In waters where there was sufficient natural alkalinity to react with the alum, the determination of the optimum is a simple matter, as it is only necessary to run a series with various amounts of alum. Where there is required additional alkalinity the tests were complicated by the two variables. In the latter case a series of jar tests must be made for each quantity of alum, with the amount of alum the same in each jar and added alkali varied. In each case the pH is carried to a point on acid side where no floc forms after hours, and similarly on the alkali side to a point of no floc formation.

Tables 4, 5 and 6 will illustrate a typical set of tests.

In table 4 the alkalinity of the raw water was 21 p.p.m., which was sufficient for the necessary alum. If sufficient alkali had been used to bring pH on no. 5 test to 5.5 an excellent floc was formed. This is the water designated no. 1 in table 1.

The water in table 5 is the one listed in table 3 from Hamlet. It has fairly high color and no turbidity.

Table 6 shows data on the water listed in table 2 as Concord. It will be noted that there is no color and the natural alkalinity is 39 p.p.m.

The tables 4, 5, and 6 will give an idea of how each test was carried out. It is not considered necessary to burden this paper with the mass of figures producing the optima tabulated in tables 1, 2, and 3.

HIGH OPTIMUM WATERS

It is rather difficult to offer explanation of the high optimum waters. The chemical contents do not differ appreciably from those with lower optima. An important fact, however, is that there is quite a difference in the alkali requirements on these waters from that of the 5.5 series. It is generally true that the latter require about 6 parts per million for every grain of alum per gallon. In the case of the waters at Charlotte, Concord, Gastonia, Wadesboro, etc., in table 2, although there is found more than enough natural alkalinity to react with the alum added, it is necessary to add excessive amounts of alkali to get a good floc. In the case of Charlotte the raw water alkalinity was 21 p.p.m. and this should be entirely sufficient for 2 grains per gallon of alum. However, it was necessary to add 30 p.p.m. additional alkalinity to get the best floc. It was not possible to get CO_2 determinations on the various waters, but at Charlotte and Wilmington these are recorded daily and do not show appreciable differences.

HIGHLY COLORED WATER

The highly colored waters show low optima. The excessively highly colored waters at Wilmington, Elizabeth City and Hertford require optima as low as 4.5, while partly colored waters at Hamlet and Lumberton may run as high as 5.6. The water at Wilmington has been especially studied, Mr. Geo. D. Norcom, in charge of the filter plant, having made numerous pH determinations during the last year. This is typical of the highly colored waters, and a low alkalinity treatment was worked out for it by the author in 1916, and is still in use. This treatment (*Engineering Record*, June 2, 1916) consists in adding only enough alkali to give 4 p.p.m. for each grain per gallon of alum, and adding additional alkali in a second basin, the principles involved in the precipitation of colloids prompting this treatment as explained at that time. The Elizabeth City water and that at Hertford act similarly.

A very interesting condition exists at Wilmington. Just below the filtration plant, the Cape Fear river forks forming the main Cape Fear Northeast branch. The main river usually is a low colored, high turbidity water, while the Northeast branch is highly stained from cypress swamps. Up to very recently water has been taken from the Northeast branch, where the tidal changes furnish a clear colored water at times and at others a mixture of this with the main Cape Fear water. The tests on the Wilmington water under table 3 are made on this colored Northeast water and show an optimum of about 4.5. Recently the intake was extended across to main river, and the Wilmington tests under table 1 are made on the new water. Thus we have the main river showing an optimum about 5.5 and its branch fed from Cypress swamps showing the lower optimum.

CONTROLLING THE pH BY ADDING ACID

In the case of the Tar river waters tests 1–7 in table 1, sulphuric acid was used with the results that as good floc was formed using 0.5 grain per gallon alum as were 1.5 grains was required without acid. It was necessary to add 1.5 g.p.g. alum before the optimum of 5.6 was reached and by adding just sufficient sulphuric acid to produce a pH of 5.6 with 0.5 g.p.g. alum similar results were accomplished.

All attempts to cut down the pH of the highly colored waters with sulphuric acid, thus reducing the amount of alum required, were unsuccessful.

COLLOIDAL CLAY AND COLOR AS A REASON FOR VARIABLE OPTIMA

A possible explanation of the variable optima lies in the colloids in the water. Clay in colloidal state has a negative electric charge and color a positive charge. The fairly heavy clay particles have no influence. The whole process of coagulating water has two stages. The first reaction is entirely a chemical one, where definite amounts of alkali combine with definite amounts of aluminum sulphate with the formation of aluminum hydrate. Even with the tests where the pH is too high or too low and no good floc is formed, there is, except when too little alum is used on a highly colored water, a smoky appearance showing the formation of aluminum hydrate. This aluminum hydrate is held in a colloidal state and must be thrown down by physical means. There seems to be required a definite pH

or definite electrical charge to precipitate the positively charged aluminum hydrate and negatively charged coloring matter and clay particles.

VALUE OF pH PLANT CONTROL

Thus far the practical application of the pH determination indicates valuable assistance to the plant operator. Having determined the optimum pH it is only necessary to take samples of water from the mixing chamber and determine the pH. If below the optimum, more alkali should be added and, if above the optimum, alkali is reduced. If supposed optimum is shown and poor floc is forming, it would suggest a change in optimum, and a redetermination of this is made. Our experience so far shows that the optimum does not change frequently. In the case of the Tar river tests (table 1, tests 1 to 3) the first test was made in August after a long dry spell, the second test in October after heavy rains and the third in February during cold weather conditions. In each case the optimum was the same.

Our experience also indicates that coagulation taking place at the optimum pH, gives a heavy, well-defined floc, and that it takes place more rapidly, thus requiring less mixing chamber and coagulation basin retention time. Attention is especially called to the influence of this control of coagulation on mixing chamber design.

CONCLUSIONS

1. The majority of waters in North Carolina coagulate most satisfactorily at an optimum pH of approximately 5.5. Highly colored waters require a much lower optimum, approximately 4.5 pH. Some turbid waters, free from color, have a much higher optimum, varying from 6.5 to 7.5 pH.

2. A technique sufficiently simple for the average small plant operator may be devised for determining hydrogen ion concentration in water purification control.

3. Experience on a number of waters in North Carolina indicates that the pH determinations furnish a valuable assistance in securing more effective and economical results.

4. There is considerable variation in the optimum for various waters and it is necessary that large numbers of waters throughout the country be investigated in this respect, before all facts in regard to pH control may be definitely determined.

DISPOSAL OF WASTES FROM DYEHOUSES AND TEXTILE OPERATIONS[1]

By Albert O. True[2]

Satisfactory and economical methods for the disposal of industrial wastes have been the subject of investigation and experiment for over fifty years. The rapid development of the manfuacturing industries about the middle of the last century, due to the extended application of steam and water power, was accompanied by a corresponding increase in the number and amounts of waste matters. A large percentage of these wastes originate in dyehouses and various textile operations.

A very noticeable pollution of streams has resulted from the direct discharge therein of unpurified waste waters from industrial plants subsequent to the establishment of the factory system.

At first, little effort was made to lessen the pollution of streams by these wastes. This was probably due to the fact that many of the early mills were located on relatively large streams affording water power, and consequently having a volume of flow sufficient to dispose of the wastes by dilution without nuisance; and partly to the failure of the governing authorities to realize the increasing damage to water supplies from these discharges.

Complaints from riparian owners against the use of streams as a medium of waste disposal, and the growing appreciation of the relation of stream pollution to public health and convenience, in time influenced boards of health and commissions governing public water supplies to investigate these conditions with a view to their prevention.

The awakening to the possible evils of uncontrolled stream pollution resulted in the passage, in several states, of legislative acts aimed to prohibit the discharge into state waters of industrial wastes. In some instances, boards and commissions with extensive powers, derived from these acts, undertook to enforce immediate abatement

[1] Presented before the North Carolina Section meeting, November 15, 1923.

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of stream pollution. This proved impracticable and unattainable except by destroying the industries concerned. A realization of this fact compelled a more reasonable attitude of public officials toward these problems, and a policy of coöperation rather than coercion has gained ground. Those states which have had to consider stream pollution, only in late years, are profiting by the mistakes resulting from this early legislation.

At first, factory and mill owners were slow to take steps to purify their industrial wastes. Any treatment which might be devised would entail an outlay which, even though relatively moderate, would pay no returns on the investment. As investigation of the subject progressed, the fact was brought out, or at least emphasized, that in some industries considerable quantities of valuable and probably reclaimable products were passing out with the waste waters and therefore were lost. This viewpoint stimulated another line of investigation of the problem, namely, the recovery and utilization of products from waste matters, and consequent increased efficiency in the industry.

The adoption of methods of waste treatment by manufacturers, together with improved methods in the treatment of municipal sewage, has resulted, in many localities, in a considerable improvement of the sanitary condition of streams and rivers. There is still, however, a large field of endeavor in the improvement of conditions due to pollution of streams by industrial wastes.

Many of the works and methods now in use for the treatment of industrial wastes must be considered inefficient. This is often, though not always, due to the use of methods not adapted to local conditions. It would probably be safe to say that success in industrial waste disposal requires more knowledge of local conditions and their intelligent use than any other phase of sanitary engineering.

With the development of comprehensive sewer systems for urban areas, industrial plants availed themselves of the public sewers as a ready means of waste disposal. This tended to cause local nuisances if the wastes from many establishments were discharged into a stream in large quantity at one or several sewer outfalls, instead of being dispersed by discharge in relatively small quantities at each mill. Another complication soon arose in connection with the discharge of trade wastes into public sewers. As works for the treatment of municipal sewage were installed, it was found that industrial waste water had considerable influence on the amount and character of the

sewage to be treated. In some localities this influence, due to the small proportion of industrial waste to total sewage flow, and also to the character of the waste, had no important significance. In other places, however, so serious interference with the physical, chemical and biological functions of sewage treatment plants by these wastes was experienced or anticipated as to necessitate their exclusion from the sanitary sewers.

The successful solution of industrial waste disposal problems, in the opinion of the writer, will require the best and continuous efforts of the chemist, biologist and engineer and the coöperation of the manufacturer. It comprises a field which cannot be standardized. The changes and advances in industrial processes, and the establishment of new industries are being accompanied by changes in the kinds and amounts of wastes to be disposed of, and the appearance of new waste products.

The utilization of waste products and the reclamation of valuable elements from by-product wastes do not appear, for the most part, to offer any considerable probability of profit at the present time. Valuable elements in wash waters are small in amount, as compared with the quantity of water to be handled, and the expense of separation is usually as great or greater than the value of the elements conserved. In addition, there remains the expense of disposal of useless products.

In general, the chief and immediate aim in waste disposal is to devise an economical means of removal of these products without appreciable nuisance. As already stated, local conditions are the chief factors in determining the methods to be devised, the type and arrangement of disposal works, and the degree of purification to be sought.

With reference to the disposal of dyehouse and textile wastes, some observations, of a preliminary nature, have been made by the writer on methods of treatment of waste waters from several cotton mills.

The liquid waste from one of the mills consists largely of wash water resulting from various operations in the dyehouse. Briefly stated, it is a composite consisting of water containing small amounts of indigo dye and sodium sulphate from the blue wash boxes, the water from the white wash boxes containing caustic soda, and the wash water and expended dye liquid from the circulating dyeing machines containing sulphur colors, salt, carbonate of soda and sulphide of soda. It varies in color at irregular intervals, being black,

dark blue and dark brown. It is usually warm and sometimes hot, possibly 100°F. The total flow of this waste is something less than 30,000 gallons per day.

For some years it was disposed of by pumping to soak pits opened in the ground on a hillside near the mill. In time this ground became saturated with the waste and it became necessary to have recourse to a better means of disposal.

A chemical precipitation and a filter plant was then constructed near the mill and about three-eighths of a mile from the creek, and is treating this waste at the present time. It consists, in the main, of a receiving reservoir, a chemical house equipped with arrangements to apply calcium chloride as a precipitant, a series of six concrete sedimentation tanks, a series of sand sludge drying beds and a filtration bed of sand resting on gravel.

The waste is conveyed to the plant by gravity in a sewer pipe which discharges into the receiving and equalizing reservoir, the latter having a capacity of about 21,000 gallons. From there it flows through the chemical house and receives a continuous application of calcium chloride solution amounting to about 230 grains per gallon of waste. It then flows continuously through the six sedimentation tanks in series. The aggregate capacity of these tanks is about three days flow of waste. The discharge from the last precipitation tank occurs at the surface of the liquid, and is received on the filter bed. The latter consists of both coarse and fine grained materials 2½ feet deep, having a superficial area of 2000 square feet, and underlaid with pipe drains. The final effluent is discharged into a channel leading to the creek. Most of the sludge resulting from the precipitation accumulates in the bottom of the first two tanks. About once a week it is pumped out into the sludge filters. After draining and drying the sludge cake is removed by special hand shovels and disposed of by dumping near the plant on unused land.

The cost of installation of this plant was about $10,000. While it effects considerable removal from the waste of substances which discolor the creek, it is relatively expensive to maintain.

At another mill an entirely different procedure is being followed than that in use at the first mill. The location of this mill permits the wastes to be discharged by gravity into a reservoir built with earth embankments on the bank of the creek. From this reservoir, the liquid is pumped through a cast iron discharge main onto a clearing of some 20 acres occupying a side hill adjacent to the creek. Near the

upper side of this clearing the waste is discharged vertically to a height of about 12 feet through a number of openings in the pipe about $\frac{3}{4}$ inch in diameter. This affords a certain amount of aeration as the liquid falls in drops and splashes on the ground. The run-off is conducted by gravity over the hillside, and directed by a system of low dikes which distribute the flow and prevent direct run-off to the creek. Ultimate disposal takes place by seepage, evaporation, oxidation and absorption by plant growth. The arrangement of dikes permits the use of one-half of the dispersion area at a time, thereby permitting the other half a period of rest.

It is noteworthy that this intermittent dosing of vegetation with the dyes has produced an exceptionally heavy and luxuriant growth of grass and weeds on this disposal area.

The aggregate amount of wastes disposed of on the area just referred to is approximately 350,000 gallons per day. While this method of disposal has proved satisfactory for the conditions obtaining at these mills, it would probably be satisfactorily used only where large areas of suitable land were available to which the wastes could be pumped at reasonable expense.

The waste disposed of is a mixture of a blue wash water containing small amounts of indigo, tallow, soda ash and starch; and a dark brown water containing small amounts of basic color dyestuff, acetic acid, starch paste, soda ash, indigo, sulphur dye, sodium sulphite, bichromate of soda and copper sulphate.

The resultant waste, as pumped from the reservoir, varies considerably in quantity and character. At times it is a greyish blue, at others a pale blue and frequently a light brown.

In the summer of 1922, some studies were started on the wastes of these mills, with a view of devising improved methods of treatment and disposal of same. These have been carried on in an experimental manner to date. The information gained so far is more the result of preliminary observation than intensive study.

Most of the experiments have been on purification by chemical precipitation, although some general observations have been made on filtration, without the use of precipitants, to encourage natural bio-chemical oxidation. Past experience seems to indicate that the character of nearly all trades wastes can be improved more or less by methods which provide means of oxidation and encourage bacterial activity. The results of such experiments as have been made with the wastes from these mills indicate, however, that biological

methods of treatment are unlikely to be very successful. The dyehouse wastes have much color in stable solution. These colors have been removed only slightly by filtration. All are high in matters in colloidal solution, which have not been satisfactorily removed by filtration alone. The resulting untreated effluents from the mills are always alkaline, varying from about 500 p.p.m. to 4000 p.p.m. of alkalinity. Liquids so strongly alkaline as these wastes probably inhibit the growth of bacteria, and produce a condition unfavorable to purification by biological agencies.

Experiments have been made testing the use of sulphuric acid, calcium chloride, lime, copperas and aluminum sulphate as precipitants for the various wastes and composites.

Calcium chloride, used alone, has been fairly satisfactory as a precipitant. It appears to give best results with the indigo waters. It is cheap and easily dissolved and applied. It removes a large per cent of colloidal and suspended matters, but leaves a supernatant liquid somewhat high in color. The sludge produced by it dries readily when drained on porous beds, and forms a cake which can be removed easily and cheaply by hand. To be effective, it has had to be applied in relatively large quantities, or about 200 grains per gallon of waste.

Copperas and lime together have produced fairly satisfactory precipitation with some of the wastes, but not with others. Sulphur appeared to interfere with its action by the formation of black, finely divided sulphides.

The best results have been obtained by reducing the alkalinity of the composite waste with sulphuric acid and subsequently coagulating it with alum. Many tests were made to serve as a guide in arriving at the amount of these precipitants for best results. No extended or precise tests have been made, as yet, to determine the degree of purification obtained, but reduction of color, turbidity and total solids have been observed as indices of relative purification. These indicate that with the average composite waste satisfactory results can be obtained by treating the composite with about ½ pound of sulphuric acid and 2 pounds of aluminum sulphate per 1000 gallons of waste, or expressed in other terms, 3½ grains of acid and 14 grains of alum per gallon.

With slight agitation to diffuse the applied chemicals, rapid coagulation usually results. The resulting sludge settles almost completely in less than an hour, and occupies a space of about 0.15 of the total

volume of the waste. The supernatant liquid has been usually clear, free of suspended solids, and of a pale green or yellow color. It has some chemical odor, frequently of hydrogen sulphide, but much less than the untreated liquid. It is stable, usually remains clear, but at times becomes slightly milky on standing. When diluted with five times its volume of clean creek water it largely loses its identity with reference to color and odor.

A small experimental plant has been built capable of treating 2000 gallons of composite waste per day of ten hours. It has been in operation for about two months for five hours each day and treating 1000 gallons of the waste from the earthen reservoir mentioned above.

It consists of a measuring box arranged to deliver the waste at a uniform rate of 3⅓ gallons per minute, a chemical house for preparing and applying sulphuric acid and alum at a uniform rate, a series of mixing boxes for aerating and mixing the waste with the chemicals, a settling tank to hold five hours flow, having hopper bottoms for sludge storage and two sets of sand filters, one for sludge drying and a second for filtration of the tank effluent. The plant is operated by the continuous flow method.

The settling tank was operated one hundred and thirty hours before any sludge was withdrawn. During all this period a high percentage of settleable solids was removed. There has been no evidence of any putrid decomposition of the sludge. Reductions in color between influent and effluent of settling tank of about 75 per cent and sometimes more have been obtained. Reduction in total solids was from 28 to 60 per cent. The sludge stored in the hoppers of the settling tank was stable and there has been no ebullition of gas or other evidence of bacterial activity. The sludge drawn off from the hoppers of the settling tank by gravity and discharged onto the sludge drying filters had an odor of hydrogen sulphide, but this was noticeable only right at the filter. This sludge is black, drains readily and drys in a few days in favorable weather. No putrefactive odors have been noticed at this plant.

Two of the most important considerations in the treatment of a waste of this character by chemical methods are sludge disposal and effective means of ascertaining the amounts of chemicals needed. At this plant it is the intention to make further investigation of sludge disposal possibilities. Owing to continual, and at times large, changes in the character of the waste and the peculiarities of coagula-

tion, some means of ready chemical control is necessary. It is hoped that the hydrogen ion tests can be used to advantage to control changes in the chemical dosage to obtain the optimum conditions for coagulation.

With the establishment of a satisfactory treatment, it would contribute very materially to the efficient operation of such disposal plants, if the processes in the mills could be standardized to the end of keeping the waste waters more uniform in strength and character. The use, as far as possible, of uniform amounts of water and chemicals for various processes, and the establishment of regular periods for intermittent cleaning operations would tend to produce a waste of uniform strength and character. It is obvious that such a waste can be more efficiently treated than one which exhibits wide and sudden changes in character.

WATER SUPPLY AT THE NEW BERN, N. C., CONFLAGRATION[1]

By F. G. Godfroy[2]

On December 1, 1922, at 8:38 a.m. an alarm of fire was turned in from Box 61. Upon answering this alarm, we found that the entire saw mill, engine room and dry kilns of the Rowland Lumber Company, on Griffith Street, were in flames. The fire had reached such a stage there was no hope of saving any part of the property then involved, so all efforts were directed to prevent the spread of the fire to the planing mills, storage sheds and boiler room.

As soon as the magnitude of the fire was seen all available apparatus in the city was rushed to the scene. This consisted of two American La France pumpers and two hose wagons. Trucks were pressed into service to get hose from the fire stations until all the spare hose was upon the ground.

The Rowland Lumber Company also had a very well equipped department and two 750-gallon Underwriter pumps with a direct suction to the Neuse River. One city truck was connected to the mill supply and one to the city mains.

This fire was finally brought under control, but not until it had totally destroyed all the dry kilns, engine room and power plant, and swept through and destroyed all the docks and the lumber that was piled upon them ready for shipment.

While this fire was at its height, another alarm was turned in from Box 32, corner Queen and Pollock Streets about 1½ miles from the mill. The chief and two of the firemen answered this with autos carrying a couple of hand extinguishers, but this blaze, which was in the roof of a negro house, had been extinguished by a bucket brigade. A few minutes later another alarm was turned in from Box 47 and immediately after that an alarm from Box 42. As soon as possible the Chief had hose loaded and sent one of the trucks to answer this alarm (which was nearly a mile from the scene of the first fire).

[1] Presented before the North Carolina Section Meeting, November 14, 1923.

[2] Superintendent of Water Works, New Bern, N. C.

This last fire was the starting of the conflagration that later caused a loss of over $2,000,000 and laid in ashes 1004 buildings that ran all the way from the smallest negro cabin to the largest warehouses in the city.

When the Department arrived upon the scene of this third fire in the negro section, there were more than three blocks of buildings involved, and a 45-mile gale was blowing from the southwest. It was soon seen that we were in for a hard fight and help was wired for to Kinston and Washington, both of whom responded promptly. Kinston drove their truck through the country, and Washington came through on a special train in record time.

Upon arrival the Washington company were located at the corner of New and George Streets and was a big factor in stopping the spread of the fire in this section. We also dynamited three or four houses in this section. The Kinston company were located at the corner of Broad and Metcalf and were instrumental in stopping the spread of the fire at Metcalf and New and Metcalf and Johnson Streets. At this point several houses were also dynamited. Both of these pumpers were drawing from the city supply and in addition to this the other two pumpers of the New Bern Department were drawing from the mains on the northern edge of the fire. The fire was so situated that direct pumpage from the river was not possible. This made the situation all the harder.

This sketch of the fire is given to show the amount of water that we had to furnish. In addition to these pumpers, there were several places where there were hydrant lines connected and these had to be abandoned later without shutting down the hydrants, due to the rapid spread of the fire. In addition to this there were several hundred openings in the domestic services that were broken off and were wide open in the burned area.

In spite of this we maintained a pressure that was, at its lowest, 20 pounds on a gauge at the City Hall, over a mile from the fire.

I shall endeavor to describe how we did this. This city had recently installed a new water plant at Glenburnie Park, 2½ miles north of the city. This plant is equipped with two 900 g.p.m. electrical-driven 2-stage centrifugal pumps and one 750 g.p.m. 2-stage centrifugal pump driven by a 75 h.p. gasolene motor. There are four wells in this group that have delivered upon test 2100 g.p.m.

We have only one power line from the city limits, but inside the city limits where we have fire hazard, we have three feeders. These

feeders are so arranged that we can shift the outside line to any one of these feeders, through a system of switches on the poles that carry the wires. These circuits are called the Bern Street circuit (which normally supplies the pumping station), the Broad Street circuit which supplies the central part of the city and most of the commercial power, and the Pollock Street circuit which supplies the main business section. Each of these circuits are inter-connected with poles switches of the air break type, single pole, so that they can be closed and the feeders connected to the pumps with a minimum of trouble.

The value of this arrangement was early demonstrated, as the Bern Street feeder was burned down for over two blocks in less than thirty minutes after the third alarm was turned in. The gasolene unit was started and kept running until linemen could make the shift in switches to throw in the Broad Street line. This only lasted for possibly an hour and a half when it was put out of commission by a telephone cable falling across it. The gas unit was started again and the linemen made another shift to the Pollock Street line which was our last hope and which fortunately was undamaged. But with this arrangement we were sending current nearly 5 miles to get to a plant that was less than 3 miles from the source. When the new system was installed, we had suspended operation of a pumping plant in the rear of the City Hall that had a capacity of 750 g.p.m. This was a centrifugal pump single stage and motor driven pump. This plant had been kept in operating condition for emergency use. This unit was started and ran throughout the day and all night, without stopping or giving any trouble. We also had two 600 g.p.m. duplex steam pumps at the electric power plant, that had formerly been used to supply the city with water and were connected with the wells at that location. They had been overhauled and were being used to supply cooling water to the surface condenser of a 1250 kw. turbine. These were also connected to the city mains and gave us an additional 500 g.p.m.

We had also a new station at Glenburnie known as the No. 2 station. This station was under construction at the time. The pump was in place and connected, but the motor was not connected to the line. This was connected in a hurry and this station also gave us valuable assistance.

The Roper Lumber Company had their two Underwriters pumps connected with the City mains, but were blocked off with check valves. As soon as we saw that we were not going to be able to

maintain the service necessary with the equipment we had, we had the Roper Lumber Company remove the checks on these valves, and they started to pump raw river water. This was continued all the balance of the day and far into the night before these pumps were shut down. The Pine Lumber Company also has a 750 g.p.m. Underwriter pump and we did the same thing with this pump.

With the pumps we had in service at this time we were furnishing approximately 5000 g.p.m. and this was only sufficient to supply the four pumpers and the waste from open hydrants and broken connections at a pressure of 20 pounds. But, as we handled the situation, at no time were we without water. Only one pumper had to resort to hand suction pipe to get what water it needed and this was on the side where two pumpers were drafting from one 6-inch main.

As soon as it was possible to get into the area that had been burned, men were sent to shut off the domestic services. They worked all night, and in the meantime three of the pumpers were taken out of service and we were able to shut down the two lumber mills services. We cut these out as soon as possible so that we could work as much as possible of the contaminated water out of the mains and wash out the mains in the northern part of the city. As soon as the last pumper was called in and the pressure was nearly normal, we connected a tank of chlorine gas to the base of the standpipe and put a direct line into the 12-inch main leading from the standpipe, and put 50 pounds of hypochlorite of lime in the top of the standpipe (capacity 160,000 gallon). This was given a few minutes to settle to the bottom of the standpipe and dissolve. Then the pumps were stopped and hydrants were opened in sections of the city that were calculated to get the best results in removing any bad water that might still be in the system.

These hydrants were kept open until the presence of chlorine gas was readily detectable at each hydrant, then this was closed down.

This nearly drained the standpipe. While we were in this shape an alarm of fire came in from the edge of the burned district, and this necessitated some quick work to get the hydrants closed and the pumps started. Fortunately this was a false alarm and no loss resulted from lack of water at this time.

We were much indebted to Mr. E. B. Bain of the Raleigh Water Works for the hypochlorite that they shipped us, and to the State Board of Health who sent Mr. Baity down to help get back to normal. We are indebted to him, because through his valuable assistance we were able to get back to a safe and sanitary water supply in the remarkably short time of forty-eight hours.

ANNUAL REPORT OF THE TREASURER

I submit herewith my report as Treasurer of the American Water Works Association for the year ending March 31, 1924.

The funds of the Association are on deposit with the United States Mortgage and Trust Company at their bank located at 55 Cedar Street, New York, the transfer from the branch located at 73d Street and Broadway having been made when the location of the office was changed to 170 Broadway. The bank was selected in 1921 by vote of the Executive Committee.

RECEIPTS AND DISBURSEMENTS, APRIL 1, 1923 TO MARCH 31, 1924

Receipts		
Balance on hand April 1, 1923	$ 4,151.65	
Received from secretary	22,463.86	
Interest on deposits	190.04	
Interest on investments	497.14	
Total		$27,302.69
Disbursements		
Expended in payment of vouchers aggregating 216 in number and comprising vouchers 1391–1606, both inclusive. (Checks bearing the same numbers as the vouchers have been drawn, with the exception of those vouchers which cover charges made by the bank on check collections, and the amount of these vouchers is set forth separately below)	$22,906.50	
Exchange on checks as charged by bank, omitting charge for March, 1923, which was included in previous annual report, and including charge of $3.55 for March, 1924, for which no voucher has been drawn, and making a deduction of $1.40 from the total of the vouchers drawn due to the vouchers exceeding the actual bank charges by this amount	27.56	
Bank deduction for 7 checks returned for further endorsement	71.90	
		23,005.96
Balance, April 1, 1924		$4,296.73

Cash balance at close of business March 31, 1924 as shown by March statement of the United States Mortgage and Trust Company		$4,767.16
From this balance there should be deducted for unreturned checks the following:		
No. 1409	$2.30	
No. 1448	0.18	
No. 1512	1.57	
No. 1546	3.96	
No. 1578	1.74	
No. 1579	0.33	
No. 1590	75.00	
No 1592	10.00	
No 1593	18.00	
No 1597	125.00	
No. 1599	232.35	
Total		470.43
Net bank balance		$4,296.73

The receipt for interest on investments does not include $42.50 which became due on March 15, but which had not been deposited by the end of March. It is to be noted that there is a difference of $94.69 in the cash balance shown by the secretary and that shown by the treasurer. The two balances do not exactly agree due, in general, to the secretary including vouchers which have been drawn by him before the end of March, but which have not reached the treasurer by March 31.

The receipted vouchers have been returned to the secretary. The cancelled checks and deposit slips, with the book of the treasurer, are available for audit.

The permanent fund has not been changed during the year and consists of the following bonds which are in a safe deposit box at the United States Mortgage and Trust Company, 73d Street and Broadway, New York City.

4 $1000 Dominion of Canada 5 per cent	$4,000
1 $1000 U. S. Liberty 2d 4¼ per cent	1,000
2 $1000 U. S. Liberty 3d 4¼ per cent	2,000
2 $1000 U. S. Liberty 4th 4¼ per cent	2,000
3 $1000 U. S. Treasury 4¼ per cent	3,000
Par value of permanent fund	$12,000
Interest on permanent fund	540

The treasurer received no salary, and is under $10,000 bond which has been placed by the Finance Committee.

ANNUAL REPORT OF THE TREASURER OF THE ELECTROLYSIS FUND

I submit herewith my report as treasurer of the American Water Works Association, for the electrolysis fund for the year ending March 31, 1924.

The electrolysis funds are on deposit with the United States Mortgage and Trust Company at their bank located at 55 Cedar Street, New York.

RECEIPTS AND DISBURSEMENTS, APRIL 1, 1923 TO MARCH 31, 1924

Receipts		
Balance on hand April 1, 1923	$1,298.87	
Interest on deposits	25.26	
Total		$1,324.13
Disbursements		
None		
Balance April 1, 1924		$1,324.13

(Signed) WM. W. BRUSH,
Treasurer.

REPORT OF THE FINANCE COMMITTEE FOR FISCAL YEAR ENDING MARCH 31, 1924

Your Finance Committee presents the following report on the financial operations for the fiscal year ending March 31, 1924. The books of the Secretary and Treasurer have been audited and found correct. All vouchers have been examined and verified.

The details of the financial affairs of the Association as set forth in the respective reports of the Secretary and Treasurer are in accordance with their books.

OPERATING INCOME AND EXPENSES

Your Committee has examined and audited the books of the Treasurer and of the Secretary and has found them to be correct and their cash balances to agree. For the reason that there are certain compensating receipts and expenses such as reprints of author's papers, binding cases, etc., representing initial outlays which later are returned, reports of the Secretary and of the Treasurer do not exactly agree, although both are correct.

Your Committee has taken the figure as submitted by the Secretary, eliminating compensating expenses and repayment of same for use in this report.

The financial committee by direction of the executive committee recommeded at the convention held at Detroit last year a budget calling for the expenditure of $23,000.00, which was approved by the convention. This budget was an increase of $4,528.16 over the actual disbursements of the fiscal year 1922-1923. The actual expenses for the past year as shown by the Secretary's report were $21,915.27, while the operating income as shown by the same report was $22,182.91, which makes a net profit from operations of $267.64. At the beginning of the last fiscal year, April 1, 1923, cash balance held was $3,934. 40, and at the close of the year $4,202.04, showing an increase of $267.64.

SUMMARIZED STATEMENT OF ACCOUNTS FOR THE FISCAL YEAR ENDING MARCH 31, 1924

Balance held in bank April 1, 1923	$3,934.40	
Net income from all sources	22,182.91	$26,117.31
Total operating expenses	$21,915.27	
Balance held	4,202.04	$26,117.31

Permanent fund of the Association is invested as follows:

PERMANENT INVESTMENT FUND

4 1000 Dominion of Canada 5 per cent Bonds, due April 1931	$4,000.00
1 1000 United States Second Liberty Bond, 4¼ per cent	1,000.00
2 1000 United States Third Liberty Bonds, 4¼ per cent	2,000.00
2 1000 United States Fourth Liberty Bonds, 4¼ per cent	2,000.00
3 1000 United States Bonds, 4½ per cent, due 1953	3,000.00
Total	$12,000.00

The committee believes that the permanent funds of the Association should be maintained at all times at not less than $12,000.00.

BUDGET ALLOWANCES AND DISBURSEMENTS

Last year's budget total of $23,000.00 was sufficient to cover all needs and all items came within the amount allowed.

The following is a statement of budget allowance and disbursements for the past fiscal year.

	Budget 1923	*Disbursements 1923*
Convention expenses	$1,200	$1,147.74
Office expenses	1,500	1,466.82
Committee expenses	2,250	1,305.92
Section expenses	1,080	887.79
Secretarial expenses	4,000	3,973.33
Salary of editor	1,500	1,500.00
Printing of JOURNAL	10,000	9,998.38
Rent of office	1,080	1,077.50
Insurance	75	42.00
Contingencies	315	315.00
Exchange on checks		27.36
Binding cases		11.93
Electrolysis Committee Reports		2.00
Office equipment		159.50
	$23,000.00	$21,915.27

The items charged against contingencies during the last fiscal year were distributed as follows:

Traveling expenses, Editor, Secretary, and Treasurer	$168.00
Membership campaign	73.87
Dues Fire Chiefs Association	60.00
Red Cross stamps	13.13

EXPENSES FOR THE CURRENT FISCAL YEAR

For the past three years your Committee has recommended a budget larger than the estimated income with the idea of using if necessary the available cash balance to make up a possible deficiency.

Fortunately our Association has had a healthy growth during these years and not only has it been unnecessary to draw on the cash surplus to meet running expenses, but the surplus has actually increased until it amounted to $4,202.04 on April 1, 1924. Our membership has shown a decided increase in the past year and our activities have so increased that your Committee believes that it is warranted in assuming a decided increase in membership this coming year and so feels safe in recommending a substantial increase in the budget and recommends for the year 1924-1925 one totalling $30,000.00.

1. Convention expenses	$1,400.00
2. Office expenses	1,750.00
3. Committee expenses	2,550.00
4. Section expenses	2,000.00
5. Insurance	50.00
6. Secretarial	5,500.00
7. Salary of editor	2,000.00
8. Printing of JOURNAL	13,500.00
9. Rent of office	1,050.00
10. Contingencies	200.00
	$30,000.00

Convention expenses have been increased $200.00 as our expenses at the 1924 convention are liable to be increased materially over last year.

Committee expenses have been increased because the proposed Manual will increase their activities and consequently their expenses.

For years our section meetings have felt the need of proper reporting of their discussions and now that our financial condition is

so much improved your Committee feels that ample funds should be allotted them so that stenographic notes can be taken of their discussion.

By action of the Executive Committee the position of Secretary Emeritus with an annual salary of $1500.00 was created and this accounts for the increase in secretarial expense.

The editing of the JOURNAL now requires not only painstaking effort, but a continually increasing amount of time which the proposed salary of the Editor covers only in part.

Whether the JOURNAL shall be published in six or eight numbers per year is not for your committee to decide, but it is considered proper to provide sufficient funds to meet the latter possibility.

In recommending the above budget your Committee is not actuated by the idea that because the money is available it must be expended, but with the idea that by these expenditures the Association can be made stronger and more beneficial to its members, provide information and discussions which will increase their knowledge and improve their treatment of the varied water works' problems which come before their members for solution.

Your Committee further feels that the sums appropriated for the various items are ample and that by the same careful administration exercised in the past a substantial balance should remain at the end of the 1924-1925 fiscal year.

Your Committee would further recommend that consideration be given to changing the fiscal year so that it would agree with the calendar year.

AVAILABLE RESOURCES FOR THE FISCAL YEAR, 1924-1925

On April 1, 1924, there was a total membership of 1936 divided as follows:

Active	1624
Corporate	147
Associate	157
Honorary	8

This is a total increase of 234 for the year, against 104 for the fiscal year 1922-1923.

Based on the above the income would be as follows:

Total from annual dues	$14,913.00
Estimated initiation fees and dues	2,400.00
Estimated income from advertising and subscriptions	8,500.00
Interest on investment	750.00
Sales of JOURNAL, etc	237.00
Total estimated income	$26,800.00
Cash surplus	4,202.04
	$31,002.04

Your Committee believes this is a conservative estimate of income.

The Treasurer is under bond for $10,000.00 and the Secretary for $2,000.00 in accordance with the order of the Executive Committee and those bonds are in the custody of the Chairman of the Finance Committee.

Your Committee further recommends that the Executive Committee designate those persons whose expenses to this convention are to be paid by the Association. Your Committee also recommends that no expenses properly chargeable to any other budget shall be chargeable to the contingent fund and that all items chargeable to contingent fund for the fiscal year be listed in the next report.

Your Committee would suggest that a vote of thanks be given to the Secretary, J. M. Diven and also to the Treasurer, William W. Brush, for their efforts in behalf of the Association and the manner in which they have taken care of the financial affairs during the past years.

Respectfully submitted,
GEORGE N. SCHOONMAKER,
E. J. NUEBLING,
GEO. C. ANDREWS, *Chairman*,
Finance Committee.

DISCUSSION

STANDARDIZATION OF SERVICES[1]

I have been especially interested in that part of the committee's report which relates to the action of water on lead pipes, for it is a subject to which I have given some study. Investigations of medical scientists indicate that lead poisoning is more frequent than is generally supposed. Most of its causes are connected with industrial processes, but the action of water on lead pipe is still one which needs to be reckoned with. The problem is not as acute, however, as it was fifty or seventy-five years ago, because lead is not used as much for service pipes and in plumbing systems now as then.

The other evening I was looking over an old book in my library, "A Collection of Reports and Opinions of Chemists in Regard to the Use of Lead Pipe for Service Pipe," compiled by the distinguished engineer, James P. Kirkwood, and published in 1859 by Hosford and Company, New York. It was evidently prepared in connection with a study of the new supply, "Nassau water," of the City of Brooklyn, for pasted in front of the book was a copy of the Rules and Regulations adopted by the Board of Water Commissioners of the City of Brooklyn, April 16, 1859. These rules specified the conditions under which the mains might be tapped, in brief as follows:

The service-pipe had to be laid "sufficiently waving to allow of not less than 1 to 1½ feet of extra length and in such manner as to prevent rupture by settlement." Depth, 4 feet in sand and 5 feet in clay. Weights of lead pipe by different sizes were specified. Block tin or zinc pipe might be used instead of lead. Galvanized iron pipe or iron pipe lined with cement might be used by persons specially licensed, provided there was a waving piece of lead pipe 4 feet long between the iron pipe and the main. Plumbers who installed service-pipes were required to be licensed by the Water Commissioners and were required to make "full returns of the ordinary and special uses for which the water was designed to be applied under the permit," together with a description of "all the apparatus and arrangements for using the water," and surveyor's measurements sufficient to locate the service and its connection. To receive a license the plumber had to be a citizen, 21 or more years of age, and

[1] Journal, May, 1924, page 649.

endorsed by two other plumbers as a person "regularly educated to the business." A bond of $1000 was also required. (This is an early example of a plumber's license, but it had to do with water pipes and not drain pipes as at present.)

The book contains opinions on lead by Dr. Thomas Clarke, Professor of Chemistry, Aberdeen University, Scotland, who devised the soap test for hardness and the water softening process which bears his name; by Angus Smith, of Manchester, England, well known for his coal-tar pipe-coating; by B. Silliman, Jr., of Yale; and by E. N. Hosford, of Harvard, both noted chemists. Dozens of opinions are given by chemists, physicians, plumbers, in England and America, the book having over 350 pages. The most elaborate report is that of E. N. Hosford, Rumford Professor of Chemistry at Harvard, who made an elaborate study (38 pages) for the Board of Consulting Physicians appointed to study the action of the Cochituate Water Supply of Boston upon Mineral Substances, dated April 3, 1848.

The conclusions reached by the various scientists quoted were substantially the same as those recorded in the report of the committee now under discussion, namely, that soft waters, colored, swampy waters, and waters containing carbonic acid are especially likely to corrode pipe to such an extent as to put lead into the water in dangerous amounts. Kirkwood emphasized the danger of allowing water to stand in the pipe and approved the custom of letting the water run long enough each morning to change the water in the pipe before using it.

There is another possible source of lead which should not be lost sight of, namely, deposits of lead ore. These exist in the Merrimack Valley, Massachusetts, a notable example being the so-called silver-mine of Newburyport. The writer has occasionally found lead even in waters at the source before coming in contact with lead pipes.

Several years ago samples of tap water in the City of Providence showed a median occurrence of about 0.5 part per million of lead. In order to be on the safe side and protect the consumers against lead, calcium hydrate was added to the filtered water to neutralize the carbonic acid. The result of this has been to reduce corrosion to such an extent that the median amount of lead in the water is now about 0.05 part per million, while most samples contain none.

There seems to be a growing tendency to pay attention to lead in water and to reduce the permissible amount. Whereas ten or twenty years ago the writer would have placed the limit as 0.5 or 0.3 part per million, he would now place it as low as 0.1 part per million.

The problem of choosing the best material for serving as service pipe seems bound to increase in importance. As a rule, plumbers take little note of the character of the water, not realizing that there is a complementary relation between the character of the water and the character of the pipes conveying it. The use of chemicals in water is becoming so general that the problem will have to be studied in the future with increasing care.

G. C. WHIPPLE.[2]

STREAM GAGING IN NORTH CAROLINA[3]

The continuous measurement of the amount of water flowing in the streams of the state is of great importance. Water power developments and municipal water supplies are based upon the knowledge of stream flow thus obtained. Moreover, the amount of sewage or trade wastes which may safely be discharged into the streams without menace to the public health or creation of nuisances depends directly upon the quantity of water flowing. Isolated measurements are not sufficient for these purposes. The daily stream flow for years is required, covering periods of extreme flood and extreme drought. The longer the record the more valuable it becomes.

The number of gaging stations maintained on streams in North Carolina has increased from 10, in 1920 when the Water Resources Division of the North Carolina Geological and Economic Survey was established, to 46 at present, as shown below:

1920 (June)	10
1920 (December)	17
1921	28
1922	33
1923	46

The locations of the present gaging stations are shown in table 1. During the year two stations have been discontinued. That at Donnaha on the Yadkin River was found to have produced erroneous data since 1917, due to improper recording by the local observer. Since there are excellent stations now on the river, both above and

[2] Professor of Sanitary Engineering, Harvard University, Cambridge, Mass.

[3] Discussion of paper by W. E. Hall and C. C. Covert before the North Carolina Section meeting, November 14, 1923.

TABLE 1

Gaging stations maintained jointly by United States and North Carolina Geological Surveys

Tennessee Basin	
Hiwassee River, at	Murphy, N. C.
Hiwassee River, at	Reliance, Tenn.
Nottely River, at	Ranger, N. C.
Valley River, at	Tomotla, N. C.
Shooting Creek, near	Hayesville, N. C.
Little Tennessee River, at	McGhee, Tenn.
Little Tennessee River, at	Judson, N. C.
Little Tennessee River, at	Franklin, N. C.
Cheoah River, near	Johnson, N. C.
Tuckasegee River, at	Bryson, N. C.
Tuckasegee River, at	East LaPort, N. C.
Oconalufty River, at	Cherokee, N. C.
Cullasaja River, at	Cullasaja, N. C.
French Broad River, at	Dandridge, N. C.
French Broad River, at	Oldtown (near Newport), Tenn.
French Broad River, at	Redmond, N. C.
French Broad River, at	Asheville, N. C.
French Broad River, at	Blantyre, N. C.
Pigeon River, at	Newport, Tenn.
Pigeon River, near	Crabtree, N. C.
Little Pigeon, at	Sevierville, Tenn.
Swannoaoa River, at	Biltmore, N. C.
Davidson River, near	Brevard, N. C.
Nolichucky River, near	Greenville, Tenn.
North Tow River, at	Spruce Pine, N. C.
Watauga River, near	Elizabethton, Tenn.
Watauga River, near	Butler, Tenn.
New River	Va.
Atlantic drainage	
Roanoke River, at	Old Gaston, N. C.
Roanoke River, at	Bugs Island Va.
Roanoke River, at	Roanoke, Va.
Cape Fear River, at	Fayetteville, N. C.*
Cape Fear River, near	Lillington, N. C.
Morgan Creek, near	Chapel Hill, N. C.
Yadkin River, at	High Rock, N. C.
Yadkin River at,	Salisbury, N. C.
Yadkin River, at	North Wilkesboro, N. C.
Deep River, at	Ramseur, N. C.†

*Abandoned September, 1923.

† Established, November, 1923.

TABLE 1—*Continued*

Deep River, near	High Point, N. C.
Fisher River, near	Dobson, N. C.
Santee River, at	Ferguson, S. C.
Linville River, at	Branch, N. C.
Chattanooga River, near	Tallulah Falls, Ga.
Dan River, near	Pine Hall, N. C. (Stokes Co.)
Dan Creek, near	Gastonia, N. C.
Moccasin Creek, near	Zebulon, N. C.
Some stations are to be added soon, such as	
Mills River, near	Mills River, N. C.

The Lillington station is used to replace Cape Fear River at Fayetteville which is not satisfactory. Roanoke River at Bugs Island, Va., will also probably be discontinued soon.

The above list shows 46 active stations on North Carolina streams at present.

below Donnaha, ample records of the flow of the river are being obtained. The station at Fayetteville was re-established during the fall of 1922. Attempts to rate it failed, due to the locks below influencing the control. Accordingly the station was discontinued in September and a station established at Lillington to replace it.

The stream gaging work has continued to be carried on in co-operation with the United States Geological Survey. This organization has a highly trained corps of engineers whose entire time is devoted to stream gaging work. Accordingly, they can carry on this work much more expertly and economically than any local state organization. The State Survey turns over a large portion of its stream gaging funds to the United States Geological Survey, which performs most of the stream gaging work and compiles and publishes the data. The State Survey indicates where new stations are to be located and, in general, exercises a constant and close inspection over all stream gaging carried on in the state. As the District Office of the United States Geological Survey is located at Asheville, the State Survey forces frequently make stream gaging measurements on streams in the Eastern Piedmont part of the state both to save expense and to obtain flood and minimum discharges which often occur only for a day or two, and thus could not be obtained by the engineers from the Asheville office.

That the stream gaging work is of direct benefit to engineers and others in the state is well exemplified by the many requests for

data of this sort. During the past year 35 requests for stream flow data have been made to the Chapel Hill office and 23 requests to the Asheville office. The majority of these requests have been for use on water power projects, though many have also related to municipal water supply developments. These requests are in addition to the very large number of engineers who regularly get their data on stream flow from the publications of the United States Geological Survey, where all the stream flow records in the state are published. These publications give only monthly and daily average flow for each single year. Moreover, these publications frequently are not issued until two or three years after the data to which they apply have been collected. Thus at present the latest bulletin on stream flow issued by the United States Geological Survey is for 1920.

Another instance of the value of the records of stream flow collected and analyzed by the Survey is evidenced by coöperation with the State Highway Commission. Before final acceptance of designs for large new bridges, it has become the custom for the Commission's engineers to consult with the Survey's Hydraulic Engineer as to the necessary waterway to allow under the bridge, the magnitude of probable floods, and the velocities to be expected in these. Thus, in the proposed new bridge across the Cape Fear River, near Elizabethtown, it was possible to save some $100,000 over the original design for the bridge after consultation with the Survey's Hydraulic Engineer made clear what area of waterway would suffice and yet not produce excessive velocities. Similar conferences were held in connection with the design of the new bridges across the Yadkin River. The Highway Commission, in turn, has coöperated with the Survey by making free of charge certain photostats which could not be obtained elsewhere in the state.

Two new automatic gaging stations have been established during the year, one at Ramseur in connection with the Deep River investigation, and one at Morgan Creek near Chapel Hill. The Roanoke Power Company has arranged to pay $1500 toward the establishment of an additional automatic station, of the most approved pattern, at Old Gaston. The establishment of new gaging stations on streams already developed is greatly limited owing to the necessity for automatic gages on such streams. The cost of this kind of installation varies from $600 to $1500 and can be made, with present funds, only when most of the expense of installation is borne by private interests. Additional stream gaging funds are needed for the establishment of automatic stations by the Survey.

Isolated stream gagings have been made by the Survey's engineers for a number of private interests. Requests for this kind of work are met whenever practicable, and the persons making it are charged the usual commercial rate for such services plus expenses. Generally gagings of this sort are requested by individuals wishing to develop some small stream for power, or fishing, or water supply purposes. They wish the Survey to do the measuring of stream flow because of its accurate methods and from the fact that its opinion on the adequacy of stream flow is valued.

Notwithstanding the continued increase in the number of gaging stations in the State (North Carolina now has more gaging stations in operation than all the other South Atlantic States together), many more such stations are urgently needed if the necessary data for new power developments and municipal water supplies are to be collected. The need for stream flow data from small streams likely to be used for municipal water supplies is especially pressing. Municipalities in the state have spent hundreds of thousands of dollars unnecessarily on account of inadequate estimates of stream flow for water supply purposes. Additional funds are needed to be spent solely on stream gaging studies in connection with possible water supplies.

Work has continued during the past six months upon the preparation of a stream flow bulletin for North Carolina, revising Bulletin 20 of the Survey, and bringing it up to date. It is expected that the new Bulletin will be ready to go to press in the spring. When issued it will be the most comprehensive publication on stream flow ever issued by any eastern state. It will show by means of diagrams the weekly flow at every gaging station ever maintained in the state, for the period of record, and also the per cent of time during which such stream flows occur in the average and minimum years. It will present also the usual tables of monthly, mean maximum and minimum stream flow on each stream for each year of the period of record. Many of the engineers of the state are eagerly awaiting the publication of this Bulletin, which will undoubtedly be of great value in enabling proper developments to be made of the water resources of the state. The Bulletin will follow in general the scheme recommended by an expert committee of the United Engineering Societies.

The amount of work expended in preparing this Bulletin may be appreciated when it is recollected that there are 46 gaging stations in the state, that some of them have been in operation for 25 years, and

that each week for the entire period of record has been tabulated and plotted, both in order of its occurrence each year and also in order of magnitude for each year. The tables and diagrams have been so arranged that hereafter annual additions may be computed quickly and the record be brought up to date easily and cheaply. It is intended to have the data complete through 1923 when the Bulletin is issued ; then to issue annual additions each year thereafter, and every ten years to issue a revision of the entire Bulletin.

THORNDIKE SAVILLE.[4]

ERRATUM

JOURNAL, May, 1924, page 717, note on "Hydrogen-ion Tests" by Frank E. Hale. In tenth line from the bottom of the page, "1 cc." should read "16 cc."

[4] Associate Professor, Hydraulics and Sanitary Engineering, University of North Carolina, Chapel Hill, N. C. Hydraulic Engineer, North Carolina Geological and Economic Survey.

SOCIETY AFFAIRS

CANADIAN SECTION

The fourth annual meeting of the Canadian Section was held in the Royal Connaught Hotel, Hamilton, Ontario, on February 27, 28, and 29, 1924. The meeting was a most successful one and five papers were presented by members of the Association, as follows:

Development of Water Purification, By Geo. W. Fuller.

Relative Economy of Standby Oil Engines, By W. S. Lea, Consulting Engineer, Montreal, Que.

Some Water Treatment Problems,[1] By A. V. Delaporte, Chemist in Charge, Experimental Station, Provincial Board of Health, Toronto.

Water Works Distribution Systems, By W. E. MacDonald, Water Works Engineer, Ottawa.

Premoulded Reinforced Concrete Pipe for Water Works Intakes, by W. C. Chace, of the Canada Lock Joint Pipe, Ltd., Toronto.

A banquet was held on Wednesday evening, at which the Mayor, members of the Board of Control and prominent civic officials were present, and Mr. Geo. W. Fuller, President of the American Water Works Association, delivered an interesting address on "Water Purification." This paper was closely followed and enjoyed by everyone present and it was broadcasted by radio for the benefit of those who were not in attendance.

After registration on the morning of the first day, the Convention opened at noon with an informal luncheon, and Mr. F. A. Dallyn, Chairman of the Canadian Section, welcomed the 150 delegates, members of the Manufacturers' Association and guests to the Convention.

On Thursday afternoon, the delegates visited the Beach Pumping Plant, as the guests of the civic officials, where modern steam turbine aud motor driven centrifugal pumps were shown working alongside the old beam engine units erected in 1859.

A most interesting display of water works equipment and materials used by water works plants was shown by the Canadian

[1] Journal, May, 1924, page 605.

Water Works Exhibitors Association. There were 36 booths in the exhibit. The desire of the members to see and investigate the commodities was clearly marked, and there is no doubt that this exhibit contributed to the success of the meeting.

At the business meeting, the annual election of officers took place, and the following gentlemen were chosen for the various positions: Chairman, Norman R. Wilson, Water Works Superintendent, Brantford, Ont.; Vice-chairman and Secretary-Treasurer, C. D. Brown, Manager, Walkerville Water Co., Walkerville.; Trustees, James Meadows, Superintendent Montreal Water and Power Company, Montreal, Que.; R. L. Starr, Water Works Superintendent Orillia, Ont., and D. M. Hanna, Water Works Superintendent, Windsor.

Subsequently Mr. Brown resigned as Secretary-Treasurer, and the Executive Committee appointed Mr. A. U. Sanderson, Superintendent, Filtration Plant, Toronto, to the position.

Montreal was selected as the place of the next annual meeting, after invitations were presented from Montreal, Quebec, Ottawa, Windsor and Peterborough.

Mr. C. D. Brown was chosen to represent the Section on the Nominating Committee of the Parent Association for the election of District Trustees, and the following members were elected as the Nominating Committee of the Canadian Section for the ensuing year: R. L. Dobbin, Peterborough, Alex. Milne, St. Catherines, W. E. MacDonald, Ottawa.

The presentation of papers, together with the discussions that followed occupied the time of the members for the remainder of the session, with the exception of one evening, when a smoker was held in the Hotel Connaught and the entertainment provided was enjoyed by all the delegates.

ILLINOIS SECTION

The sixteenth annual meeting of the Illinois Section was held on Wednesday and Thursday, March 19–20, 1924.

M. S. Ketcham, Dean of the College of Engineering, welcomed the members of the association and spoke of the interest of the University in their affairs. H. F. Ferguson spoke of the filtration plant operators conference which had been held during the two preceding days and also presented details giving data of the construction and operation

of water treatment plants in Illinois. In a discussion on filter sands led by Paul Hansen the sizes of sieves and the advisability of specifying effective sizes and uniformity coefficients of sands were discussed. C. W. Parsons presented a paper on Water Works and Fire Protection of Small Municipalities[2] suggesting substantial storage capacity, duplicating of pumps and mains, use of mains larger than 4 inches, and use of hydrants in sufficient number and of sufficient size.

At the Wednesday evening session W. W. DeBerard gave views of engineering affairs as seen by an editor, citing many notable and interesting events. M. M. Leighton[3] spoke of the various water bearing strata in the State, the relation of water reservoir projects to geologic data, and information available from the State Geological Survey Division.

The officers elected for the coming year are: Chairman, A. M. Buswell, Chief State Water Survey Division; Vice-Chairman, L. R. Howson, of Alvord, Burdick, & Howson; Trustee, C. M. Roos, Secretary & Superintendent, Cairo Water Co.; Treasurer, H. E. Keeler.

Other officers are W. R. Gelston and W. E. Lautz, Trustees, and G. C. Habermeyer, Secretary.

W. W. DeBerard moved that a committee be appointed by the chairman of the section to represent the Water Works Association, Board of Health, Water Survey, and University to consider ways and means of coördinating filter plant operators conferences and Illinois Section activities. The motion was seconded and carried.

One of the two boxing matches scheduled was by members of the University of Illinois team and the other, the funniest a member had seen in a thousand years was by Mutt and Jeff (Greenfield and Swearingen.)

At the Thursday morning session W. B. Bushnell spoke of over chlorination for the control of tastes in the Champaign and Urbana Water Company supply and similar experiences at other plants were spoken of in discussion. W. U. Gallaher pointed out that alum floc is of variable composition and is probably not aluminum hydroxide. E. M. Partridge presented a very interesting paper on Boiler Compounds giving some interesting information on the preparation of boiler compounds which hitherto has not been presented to the general public. Wm. E. Stanley presented data collected by E. E.

[2]This Journal, page 781.
[3]This Journal, page 770.

Ruthrauff, chief operator of the Decatur filtration plant, showing that during the past year, since the new reservoir of about six billion gallons capacity has been in use the turbidity of the raw water has been much less and the color somewhat higher than previously. The paper on Observation of Purification-Plant Designs by S. T. Barker was read by M. LeBosquet. The new proposed bacteriological standards for drinking water would probably be more lenient in the long run than the present standards, according to the data in the State Water Survey files, presented by A. M. Buswell and R. A. Shive.

During the Thursday afternoon session G. C. Habermeyer[4] spoke of decrease in yield of wells due to reaction of waters and gave methods of measuring yields and water levels used by the State Water Survey Division. F. G. Gordon[5] spoke on Cast Iron Pipe Prices giving prices for many years and various months in the year which seemed to disprove the fact that any considerable sum has been saved by buying pipes during winter months. John W. Mabbs, President of Mabbs Hydraulic Packing Company, spoke on packing and the effect of braided rawhide for pump packing.

The attendance was about 80, including 36 members and representatives of the associate members of this section.

[4] This Journal, page 840.
[5] This Journal, page 761.

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health, **12**: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

The Chemical Treatment of Water Supply in Active Warfare and the Application of the Methods to Water Supply in Country Districts. M. J. HOLMES. Health, Commonwealth of Australia, **1**: 2, 43, February, 1923. Chlorination effected by hand in bulk or by mechanical means; as water was taken from stream, well, etc. under control of trained water man; by mobile sterilizer and stationary sterilizing plants.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Prevention of Algae in Storage Tanks. ALFRED ADAMS. Public Health, **36**: 5, 128, February, 1923. Trouble from algae in 40,000 gallon open water tank eliminated by weekly dose of one part per million of chlorine.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Rivers Pollution. C. P. JEPSON. Surveyor, **64**: 1662, 387, November 23, 1923. History of river pollution legislation in Great Britain since 1865. Trade depression and use of unemployed on public works has brought the rivers back to pre-war condition.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Treatment of Feed Water. 1923, Report of Prime Movers Committee, National Electric Light Association, Part B, 171. Effect of various water treating systems on boiler operation. Deactivation and deaeration of water by mechanical apparatus, treatment by permutit system of softening by zeolites, tests with Hagen De-Concentrator, feed water heaters, chemical treatment and evaporators described. Table gives summary of data from 36 companies operating equipment ranging from 3,000 to 34,000 square feet of boiler heating surface.—*A. W. Blohm.*

Power House Ventilation. 1923, Report of Prime Movers Committee, National Electric Light Association, Part B, 349. Under most favorable conditions, in boiler room, 12 pounds air are required per pound of coal consumed, or plant using 50 tons coal per hour would require 600 tons air per hour or 250,000 cubic feet per minute at average temperatures. Plant must be designed to replace air lost by combustion and through stack, without causing fogs in turbine rooms, collection of moisture, retaining heat in winter and releasing it in summer.—*A. W. Blohm.*

Operating Code Manual. 1923, Report of Prime Movers Committee, National Electric Light Association, Part B, 367. Revised rules covering general operation of stoker fired boilers. Revisions made to allow rules to fit general case instead of specific in all cases where this was deemed feasible.—*A. W. Blohm.*

The Precipitate from Partially Alkalinized Alum Solutions. L. B. MILLER. Pub. Health Reports, **38**: 35, 1995, August 31, 1923. Study made of composition of precipitate formed at different pH values by addition of sodium hydroxide to alum solutions. Certain precautions to be adopted in analytical determination of aluminum are stated, and reason for these given. Theoretical and experimental study of solubility of aluminum precipitate at different pH values was made, and certain conclusions drawn therefrom. Results are compared with those obtained, under varying laboratory and commercial conditions by other workers.—*Aug. G. Nolte.*

Sanitation of Tourist Camps. Pub. Health Reports, **38**: 35, 2016, August 31, 1923. Specific regulations made by State Board of Health of Minnesota are given regarding water supply, toilets, refuse disposal, and camp sites for tourists. County Health Officer best individual to assume responsibility for sanitation of all tourist camps in county.—*Aug. G. Nolte.*

Iodine Administration in Prophylaxis of Endemic Goiter. ROBERT OLESEN. Pub. Health Reports, **39**: 2, 45, January 11, 1924. Most favored method at present time is administration of chocolate tablet containing 10 mgm. iodine in form of organic acid. Preventive should be used regardless of evidence of thyroid enlargement. Use of iodized table salt holds considerable promise as efficient means of preventing endemic goiter, but difficulties of gauging dosage accurately are a handicap. Wholesale iodization of municipal water supply may be cited as ingenious method, in need of further appraisal before definite verdict as to its efficiency can be given. Many references cited.—*Aug. G. Nolte.*

Drinking Water Systems. H. J. MACINTIRE. Power, **59**: 7, 254, February 12, 1924. In first class offices and hotels, use of cold drinking water on tap is becoming common. Water usually cooled to 45°F. by means of Bandalot cooler. Flow through system must be such that even when maximum demand occurs at fountains, there must be water flowing through return line to tank. To reduce pumping work, circuits are usually limited in length to 2000 feet. Water velocities in pipes limited to maximum of 200 feet per min. Consumption is variable, depending upon temperature and upon working conditions of consumer. Hotels and Office Buildings, with outlet in each room, designed on basis of one gallon per person per day. Store and Office Buildings, with outlets in isolated places, one-half pint per min. per fountain. In factories, one-half gallon per person per hour and in offices, one-quarter gallon per person per hour. Number of fountains or outlets is variable. Good practice allows one fountain per 50-100 operators. System should be well insulated. Illustrated.—*Aug. G. Nolte.*

Furnaces for Burning Small Anthracites. A. R. MUMFORD. Power, **59**: 8, 284, February 19, 1924. Progress of combustion studied in furnace of water-tube boiler fired by two Coxe chain-grate stokers. Boiler was a four-drum Edgemoor water-tube boiler, 29 and 30 tubes wide, and 16 tubes high, containing 10,000 square feet of heating surface. Gases crossed the tubes three times in path through boiler, which was baffled by ordinary Edge Moor type baffles. Beneath stoker grate were four separate air chambers, to which air was supplied through three windboxes from a main air duct; in the studies, grates were considered to be divided into four sections, one over each air chamber. Investigation divided into five parts; (1) combustion conditions during normal operation; (2) effect on combustion of raising front arch; (3) effect of air introduced through jets under pressure; (4) effect of steam jets at rear of furnace, introduced to stimulate a rear arch; (5) effect on combustion of a rear arch installed in a furnace with a low front arch. Results of the investigation are discussed and illustrated by diagrams.—*Aug. G. Nolte.*

Testing the Effectiveness of Bearing Lubrication with an Electrical Circuit. W. V. FITZGERALD. Power, **59**: 8, 298, February 19, 1924. A brush, placed in contact with a rotating shaft was connected to one binding post of ordinary electric doorbell; other post connected to lower part of bearing pedestal, with two dry cells and switch interposed in line. As oil is fairly good insulator a thin film of it will break a contact such as is outlined above. Purpose of oil in a bearing is to reduce friction and wear to a minimum by placing between metallic surfaces a film of oil. If this film is complete, and no metallic contact occurs, electrical circuit should remain open as long as shaft is revolving. Problem was to decide between a heavy and a light oil for best lubrication for particular job. Each oil was tried in bearing with shaft rotating at normal operating speed and switch closed; test with heavy oil rang the bell spasmodically at considerable intervals; test with light oil under same conditions did not cause bell to ring. Showed that heavy oil did not maintain constant film, while light oil did. Illustrated.—*Aug. G. Nolte.*

Alternating-Current Versus Direct-Current Motors for Stoker Drive. W. E. DOUGLAS AND H. H. BATES. Power, **58**: 1, 8, July 3, 1923. In general, alternating-current motor has in its favor fact that no converting apparatus is required; except that of the brush-shifting motor, commutators in all cases are eliminated. While alternating-current motors comprise the larger proportion of such drives, direct-current motor has been used with more efficient results on many installations. Where direct-current is available without resorting to special converting apparatus, direct-current shunt-wound motor, with all field control, is best suited for stoker service.—*Aug. G. Nolte.*

Loss of Head in Valves and Pipes. Power, **58**: 2, 74, July 10, 1923. Tests were made at Univ. of Wisconsin on valves and pipes from ½ to 12 inches in diameter. Results obtained described in Engineering Bulletin No. 1, Vol. 9. Conclusions therein summarized are given.—*Aug. G. Nolte.*

The Determination of Boiler Efficiency. H. B. JONES. Power, **58**: 3, 88, July 17, 1923. Careful scientific analysis is made of errors that arise in determining boiler efficiency.—*Aug. G. Nolte.*

Coal Storage at Detroit Water-Works. Power 58: 4, 133, July 24, 1923. Coal is delivered by water. 25,000-ton shed erected to receive coal, and canal dug to Detroit River, to admit barges. Unloading by clamshell buckets and crane, into hopper with reciprocating feeder, delivering to 30-inch double-roll crusher. 24-inch inclined belt conveyor passes over integrating weightometer, and, at entrance to storage building, delivers coal to 24-inch horizontal belt, which distributes it along south wall by means of automatic self-propelling and reversing tripper. Coal is stored to depth of 20 feet and is leveled up or reclaimed by means of drag scrapers. Further details of the coal-and-ash-handling systems are given.—*Aug. G. Nolte.*

Oil Engine Operating Costs. Power, 58: 4, 140, July 24, 1923. High generating costs in small central stations, due to increased labor and coal prices, solved by Holstein Service Co., of Holstein, Iowa, by installation of two Diesel oil engines, of 165 and 180-horse power, respectively. Average kilowatt-hour output, per gallon of fuel oil, during 1922, was 9.44. Total average cost per kilowatt-hour for 581,590 kilowatt-hours generated, was $0.015.—*Aug. G. Nolte.*

Corrosion by Acid Water. D. H. Jackson. Power, 58: 6, 217, August 7, 1923. Water ordinarily called "acid" is one that will give an acid reaction with an indicator such as methyl orange. Even though most natural waters are on alkaline side of neutrality, they all have, although to a very small degree, hydrogen ions, which give to water power to dissolve iron. Best way of expressing acidity is in terms of hydrogen ions. Iron is soluble in water in proportion to the amount of hydrogen ions present. Corrosion of iron in average neutral, or slightly alkaline, natural water is very small and would automatically stop, were it not for dissolved oxygen present. This unites with the hydrogen liberated by iron-solution process and prevents polarization of the-iron. Also reacts with dissolved iron and precipitates it as iron oxide. Best and safest method of preventing corrosion is removal of dissolved oxygen.—*Aug. G. Nolte.*

Zinc in Boilers. F. M. Gibson. Power, 58: 6, 234, August 7, 1923. A number of statements made, regarding use of zinc in boilers for prevention of scale and corrosion, by subcommittee on Care of Steam Boilers, etc., of the A. S. M. E.—*Aug. G. Nolte.*

Submerged Orifices for Uniform Control of Chemical Feed. Power, 58: 7, 244, August 14, 1923. The Graver Corporation, of East Chicago, Ind., has replaced the system of weirs formerly used for control of the chemical feed in proportion to quantity of water entering a continuous water softener, by a divided flow system employing submerged orifices.—*Aug. G. Nolte.*

Auxiliary Equipment for Blast and Ventilating Fans. C. L. Hubbard. Power, 59: 9, 318, February 26, 1924. Various data on the installation and operation of fans are given. The following subjects are discussed: foundations and supports; miscellaneous fan and motor noises; fan drives (steam engine, steam turbine, electric motor, line shafting); and fan control.—*Aug. G. Nolte.*

Oil Engines Practical even if Process Steam be Needed. J. S. Le Clercq. Power, **59**: 9, 322, February 26, 1924. The Dallas Oil and Refining Co., by using Diesel for power and boilers for process steam, have obtained results that show attractive saving in power costs.—*Aug. G. Nolte.*

Burning Small Sizes of Anthracite. A. A. Cary. Power, **59**: 9, 326, February 26, 1924. Extract of discussion before Metropolitan Section, American Society Mechanical Engineers, January 15, 1924, at New York City. Firing methods for bituminous and anthracite coals are given, and progress of combustion of anthracite coal on stokers, discussed.—*Aug. G. Nolte.*

Questions and Answers. Franklin Van Winkle. Power, **59**: 9, 342, February 26, 1924. Questions are asked and answers are given on the following subjects. Evidence of Low Piston; Theoretical Power Obtainable from Pound of Coal; Turbo-Alternating-Current Generators in Parallel; Size of Exciter for Alternator; Theoretical Height of Raising Water with Steam Pump; Setting Valves of Single-Valve Automatic Engine; Stuck Piston Ring of Oil Engine; Apparent and Actual Cutoffs; Rattling of Corliss Valves.—*Aug. G. Nolte.*

Fusing Potential Transformers. C. M. King. Power, **58**: 8, 283, August 21, 1923.—*Aug. G. Nolte.*

Drum Suspension for Boilers. J. B. Crane. Power, **58**: 8, 284, August 21, 1923. Various methods of supporting boiler drums are illustrated and discussed.—*Aug. G. Nolte.*

Test of Diesel Fuel Consumption. W. B. Gregory. Power, **58**: 8, 285, August 21, 1923. Fuel guarantees of engine builders were met in every instance, while in every run but one, there was good safe margin between performance and guarantee. At a little more than full load, both engines tested used 0.43 pound fuel oil per brake horsepower per hour.—*Aug. G. Nolte.*

Writing Pipe Specifications. H. E. Collins. Power, **58**: 8, 287, August 21, 1923. To assist those responsible for the preparation of piping specifications, author submits a number of valuable ideas for their guidance.—*Aug. G. Nolte.*

Testing Jet Condensers. L. Long. Power, **58**: 8, 293, August 21, 1923. Various means of locating faults are described in a direct practical manner.—*Aug. G. Nolte.*

Questions and Answers. Franklin Van Winkle. Power, **58**: 8, 308, August 21, 1923. Questions are asked and answers given on following subjects: Breakage of Firebox Staybolts; Temperature of Water Cooled by Ice; Grounding the Neutral of Alternating-Current Generators; Extraordinary Stresses Induced by Rupture; Cleaning Grease from Gage Glasses; Temperature in Coils Supplied by Steam Through Reducing Valve; Packing Joint at End of Through Stay; Strength of Diagonal Joint.—*Aug. G. Nolte.*

Checking the Operation of Hydro-Electric Units. RALPH BROWN. Power, **59**: 10, 361, March 4, 1924. Convenient method for checking performance of a hydro-electric unit is given; probable causes for reduction in output are cited. Decrease to about 95 per cent of normal output generally indicates advisability of a thorough overhauling—*Aug. G. Nolte.*

Operation and Care of Drum-Type Manual Controllers for Motors. H. D. JAMES. Power, **59**: 10, 368, March 4, 1924.—*Aug. G. Nolte.*

Calculating the Amount of Air Liberated in Barometric Condensers. C. M. REED. Power, **59**: 10, 370, March 4, 1924. Method is presented for estimating vacuum-pump capacity required by barometric condensers and measuring air leakage into condenser installations, with numerous curves for making the necessary calculations graphically.—*Aug. G. Nolte.*

High-Head Penstock Failure Found Due to Bad Steel. Power, **59**: 10, 373, March 4, 1924.—*Aug. G. Nolte.*

Questions and Answers. FRANKLIN VAN WINKLE. Power, **59**: 10, 382, March 4, 1924. Questions are asked and answers given on following subjects: Loss of Heat in Chimney Gases; Treating Overheated Low-Pressure Crankpin; Overloaded Motor;Gasket for Leaky Ground Joint of Cylinder Head; Cutting Snap Rings; Deposit from Cylinder Oil when Using Superheated Steam; Receiver Pressure below Pressure of Atmosphere; Approximate tests of Engine Alignment; Action of Receiverless Compound Engine.—*Aug. G. Nolte.*

The Steam Accumulator and its Application. Power, **58**: 9, 322, August 28, 1923. The practical application of using large mass of hot water to store up energy of excess steam at pressures considerably above atmospheric is recent European development. Illustrated article describes the construction of high-pressure accumulator; shows how weights, capacities, etc., are figured; and outlines a few of many possible applications.—*Aug. G. Nolte.*

Care of the Venturi Meter. D. C. BROWN. Power, **58**: 9, 326, August 28, 1923. Meters should be taken out of service and cleaned at periodic intervals depending on character of service. Where installation is used for measurement of hot boiler-feed water containing scale-forming salts, accumulated deposits in throat section of tube cause increasing errors in measurement. Tube and pressure leads to register and recorder should be cleaned and all leaks taken up. Method of installation of pressure pipes for best operating results are outlined.—*Aug. G. Nolte.*

Manganese Deposit on Water Filter at Breckenridge, Texas. J. B. HAWLEY AND W. S. MAHLIE. Eng. News-Record, **90**: 834, 1923. Growth of *Crenothrix Manganifera* in force main which stood idle for 3 weeks is believed to be cause of black manganese deposit on filter sand. Water contains about 0.036 p.p.m. of manganese. No further trouble has been experienced since force main continuously in use.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Low per Capita Water Consumption in London. ANON. Eng. News-Record, 92: 159, 1924. Per capita consumption for year ending March 31, 1923, was 42 U. S. gallon. This was a decrease of 1.64 U. S. gallon from previous year. The rate is considered high by "The Engineer," as compared with that of provincial centers.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Studies under Way on Filter Efficiency Limitations. H. W. STREETER Eng. News-Record, 92: 146. 1924. A detailed study of 16 filter plants has been started by United States Public Health Service to determine just how far a supply can be polluted and still be made safe by subsequent purification.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Eductors for Washing the Rapid Filters at Zelienople, Penn. GEO. HUDSON Eng. News-Record, 92: 107, 1924. An eductor installed in this plant instead of usual reducing valve on a pressure line, wash-water pump, or high tower wash-water tank, uses two portions of water from clear well to one from high pressure tank. Is economical both in first cost and in cost of installation.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Iodine Water Treatment at Sault Ste. Marie. H. A. SHERMAN. Eng. News-Record, 92: 105, 1924. NaI was added to the city water supply at rate of 2 pounds per day for two weeks, twice a year. First application was made in August, 1923, when pumpage rate about 3 m.g.d. Object: prevention of goitre.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Typhoid in Chicago. EDIT. AND ANON. Eng. News-Record, 92: 100–1; 116–121; 1924. Typhoid epidemic last November was waterborne. Laxness by city authorities regarding frequent examination seems evident. Sampling of chlorinated water tri-weekly and of raw water much less frequently, is inadequate to protect city with 3,000,000 inhabitants. State Board of Health recommends employment of sanitary engineer, with adequate laboratory force, to take charge of water supply. Epidemic was caused by heavily polluted Calumet River flowing into Lake Michigan, from which water supply is taken.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Supervision of Water Treatment Plants in Michigan. E. D. RICH. Eng. News-Record, 92: 73, 1924. All filter plants in Michigan maintain their own laboratories. Of 50 chlorination plants, 41 have analyses made regularly. State Board requires installation of facilities for making examinations and as a result, have 50 laboratories making tests for 54 water systems. Typhoid death rate for the State is less than 5.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Chicago's Diversion of Water from the Great Lakes. ANON. Eng. News-Record, 92: 28–31, 1924. Historical review.—*Frank Bachmann.*

Alumina Cement in France. E. C. ECKEL. Eng. News-Record, 91: 347–9, 1923. New type of cement, invented about 1908: high in Al_2O_3; resistant to

sea water and sulphate waters; hardens rapidly. French army used it during war for rapid work on gun emplacements and roads. Is replacing Portland cement on road work, where long tie-ups at street intersections must be avoided. In France, output has reached 7 per cent of total Portland output.—*Frank Bachmann.*

Peebles Portable Sandwasher. ANON. Chem. Ind., **43**: 11, 269, March 14, 1924. Uses very low pressure water jet (4–5 pounds); is compact (6 by 4 by 4 feet; weighs 13 cwts.; and when mounted on wheels has overall dimensions of 9 by 4 feet 4 inches and 3 feet high. At 5 pounds pressure, machine will wash 4.15 tons sand per hour, or one ton in 14½ minutes. At three pounds water pressure, 2½ tons per hour can be handled. It is operated by series of water jets, total consumption of water at five pounds pressure being about 800,000 gallons per hour. It consists essentially of four small washing chambers, one behind the other, on an inclined plane, connected at the bottom by a cast iron pipe. The whole rests on steel axle between the wheels. The sand falls from hopper through an oscillating strainer, operated by small water motor, to separate all pebbles and larger particles. The filtered sand then falls into a chamber at bottom of which is a jet which forces sand upward and mixes it with water. Operation depends on principle that dirt and impurities are lighter than sand and are washed out on the stream of water over a wheel to a discharge, while only the heavier sand is carried over to a second chamber. Sand is propelled continuously through the four chambers in succession in this way by a series of clear water jets.—*A. M. Buswell.*

Water Used in Paper Making. ARTHUR S. M. KLEIN. Paper, **29**: 11, 12–13, 1921. From Chem. Abst., **16**: 2223, July 10, 1922. Review of water consumption as determined by various authorities.—*R. E. Thompson.*

The Determination and Separation of Aluminium. GERHART JANDER AND ERWIN WENDEHORST. Z. angew. Chem., **35**: 244–5, 1922. From Chem. Absts., **16**: 2461, August 10, 1922. Usual methods of determining aluminium are slightly inaccurate. Aluminium hydroxide almost invariably remains to appreciable extent when precipitation effected by ammonium hydroxide, ammonium sulfide, ammonium acetate, sodium thiosulfate, potassium iodide-iodate, or diammonium phosphate. Method is described in which aluminium is volatilized as chloride in stream of hydrogen chloride, collected, converted to nitrate, ignited, and weighed as aluminium oxide. Corrections for manganese and magnesium are necessary.—*R. E. Thompson.*

Exact Determination of the Sulfate Radical in Sodium Sulfate. MOTOTARO MATSUI AND SEN-ICHI KIMURA. J. Chem. Ind., (Japan), **24**: 1039-53, 1921. From Chem. Abst., **16**: 2464, August 10, 1922. From comparison of 5 methods it is concluded that minimum errors are obtained with slow method of Allen and Johnston (C. A. **4**: 1955) when corrections are made for barium sulfate in supernatant liquid and barium chloride and sodium sulfate occluded in precipitate, and with method of Johnston and Adams (C. A. **5**: 2456) when corrections are not made.—*R. E. Thompson.*

Recent Developments in Power Production. D. L. SELBY-BIGGE. J. Iron Steel Inst. (London), adv. proof, 1922, 40 pp.; Iron and Coal Trades Rev. **104**: 659–61, 1922. From Chem. Abst., **16**: 2561, August 10, 1922. Extensive review and discussion.—*R. E. Thompson.*

Report on Water. J. W. SALE. J. Assoc. Agr. Chem., **5**: 379–88, 1922; cf. C. A. **16**: 453. From Chem. Abst., **16**: 2563. August 10, 1922. Weselzszky method unsatisfactory for bromine but gave good results for iodine. Proposed procedure for small quantities of lead, copper and zinc outlined.—*R. E. Thompson.*

The Frequent Impurity of Distilled Water. A. RICHAUD. J. pharm. chim., **25**: 469–77, 1922. From Chem. Abst., **16**: 2564, August 10, 1922. Summary of sources of impurity and methods of testing.—*R. E. Thompson.*

The Determination of Hardness in Water. A. C. RÖTTINGER. Z Ver. Gas-Wasserfach. in Osterreich u. Ungarn, **59**: 13–22, 36–9; Wasser u. Abwasser, **15**: 205–6, 1921. From Chem. Abst., **16**: 2564, August 10, 1922. Titration with 0.02 N. hydrochloric acid recommended for carbonate hardness and titration with potassium palmitate for total hardness, with suitable correction for end-point. Results considered only as approximate.—*R. E. Thompson.*

The Gas Content of the Water of Lake Himmelsdorfer, near Lübeck. BRUNO SCHULZ. Naturwissenschaften, **10**: 307–8, 1922. From Chem. Abst., **16**: 2564. August 10, 1922. The deeper water of the lake contains 300 p.p.m. hydrogen sulfide, the highest content of any natural water known.—*R. E. Thompson.*

The Movements of Silt in Streams. Zentr. Bauverwaltg. **39**: 212–4, 217–20; Wasser u. Abwasser, **15**: 215–6, 1921. From Chem. Abst., **16**: 2564, August 10, 1922. Differential equations, to express horizontal and vertical velocities in flowing streams, developed. Effect of these currents on turbulence and turbidities discussed.—*R. E. Thompson.*

Commercial Preparation and Use of Fullers' Earth. T. P. MAYNARD AND L. E. MALLON. Chem. Met. Eng., **26**: 1074–6, 1922. From Chem. Abst., **16**: 2582, August 10, 1922. Property of adsorbing bases gives fullers' earth value as water softener.—*R. E. Thompson.*

The Destruction of Cement by Water and Waste Water. A. SPLITTGERBER. Wasser, **17**: 87–9, 1921; Chimie et industrie **7**: 942, 1922; cf. C. A. **15**: 4044. From Chem. Abst., **16**: 2585, August 10, 1922. Action of calcium sulphate and bicarbonate in water on cement, and precautions in disposal of industrial wastes and means of preventing penetration of these wastes into concrete.—*R. E. Thompson.*

Utilization of Compressed Air in Clearing Gas Piping. J. T. GRIFFIN. Tech. Sec. Am. Gas Assoc., 3rd. Annual Convention, **3**: 143–60, 1921. From

Chem. Abst., **16**: 2592, August 10, 1922. Compressed air at 1500 pounds pressure used for removing stoppages in service pipes, scale from house heating boilers, and obstructions in drain pipes to sewers.—*R. E. Thompson.*

Boiler Cleaners for Municipal Power Plants. W. F. SCHAPHORST. Am. City, **26**: 491, 1922; Public Health Eng. Absts., July 8, 1922. From Chem. Abst., **16**: 2747, August 20, 1922. Mechanical methods of removing scale and soot by rotary cutters or vibratory removers recommended. Boiler compounds are warned against, especially those having secret formulas.—*R. E. Thompson.*

Some Boiler-Firing Troubles. EDW. INGHAM. Colliery Guardian, **123**: 1417, 1922. From Chem. Abst., **16**: 2770, August 20, 1922. Recommendations (in original) for overcoming black smoke, cinder in exhaust gases, explosive mixtures in flue, down drafts, boiler vibration, and drop in steam pressure with coal as fuel.—*R. E. Thompson.*

Examination of Water for B. Coli. A. GAAL. Z. Unters. Nahr. Genussm., **46**: 37–43, 1923. Chem. & Ind., **42**: 1148a, November 30, 1923. The bacteria in unsterilised water are unfavorable to development of B. coli and become more so with rising temperature. B. coli keep well at low temperatures, and, when afterwards introduced into nutrient media, are even able to overcome bacteria unfavourable to them at higher temperatures. B. coli inoculated into unsterilized tap water disappeared completely on incubation at 37°C. for 24 hours. Cultures of B. coli in distilled water, however, developed well, both when kept in ice-chest and at higher temperatures for 24 hours. Unfavorable effect of higher temperatures only became noticeable after incubation for fifteen days. Experiments with water containing large amounts of salts in solution confirmed these results, development of B. coli at 37° only occuring when water had been sterilized previous to inoculation. Investigation of water samples 19 and 34 days after inoculation showed that those kept at 37°C. were free from B. coli after 19 days, whereas B. coli were well preserved in samples kept in ice-chest, and developed well on subsequent incubation at 37° in agar or bouillon. After 34 days in ice-chest, B. coli seemed to such an extent acclimatised to low temperature that colonies were formed in agar after incubation for 5 days in ice-chest. These experiments emphasise great variability of B. coli and difficulty of detecting it in certain cases. Water is only to be considered free from B. coli when indole, fermentation, and reduction tests have failed, together with all attempts to cultivate B. coli in specific media. Sample should not have been subjected to temperature higher than that of a cool room, or cellar, between time of collection and investigation (H. C. R.)—*A. M. Buswell.*

Safe Water Supplies for Isolated Houses and Small Institutions where Municipal System is not Available. Publication No. 18, Dept. of Health, Canada. 1923, 34 pp. Rural water supplies and methods of guarding against pollution are described. Fluctuations in temperature of ground waters indicate shallow origin. Ordinarily, at depth of 40-60 feet temperature is about 50°F. and

nearly uniform throughout year. Deep ground waters are usually progressively warmer, increase in temperature being approximately 1°F. for each 50–60 feet increase in depth.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Case in Which Winkler's Manganous Process for Dissolved Oxygen is Untrustworthy. J. H. Coste and E. R. Andrews. Analyst, **48:** 543, 1923. Jour. Soc. Chem. Ind., **43:** 2, B. 31, January 11, 1924. Winkler's manganous process gives erroneous results when used to determine dissolved oxygen in ammonium chloride solutions of concentrations M/2 and upwards, as precipitation of manganous hydroxide and its subsequent oxidation are greatly retarded. Gasometric determinations of the dissolved gases by Winkler's calcite and hydrochloric acid process show that ammonium chloride has an effect of the same order as that of sodium chloride in reducing solubility in water of gases of the air (H. C. R.)—*A. M. Buswell.*

Process for the Electrical Purification of Effluents from Dyestuff Factories and Dyeworks. G. D. Frank. G. P. 380, 891, 10.7. 21. Jour. Soc. Chem. Ind., **43:** 2, B. 31, January 11, 1924. Effluent passes alternately through a number of cells in which it is treated with direct electric current, and vessels in which material, precipitated by action of the current, coagulates into larger particles and settles to bottom of vessel (L. A. C.).—*A. M. Buswell.*

The Mechanical or Rapid Filter. Major F. Johnstone Taylor. Water and Water Eng. **25:** 332, September 20, 1923. Essentially a description of the Wheeler filter bottom.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Water Supply in 1922 (British). Anon. Water and Water Eng., **25:** 320–1, September 20, 1923. Abstract from the 4th Annual Report of Ministry of Health. Low rainfall in May and June gave rise to fears that deficiency of 1921 might be repeated, but year finished 4 per cent above normal rainfall. The Board is endeavoring to formulate a policy on water supplies to secure better quality and lower cost, and to prevent over-lapping. A considerable number of water and sewage schemes have been approved (including 12 activated sludge plants; 10 for agitation, and 2 for aeration) and nearly 41 million pounds sterling have been loaned by the Government. Experiments have been made at the Birmingham Tame and Rea District Drainage Board Works involving settling the sewage in tanks, a short aeration, and then passage through sprinkling filters. Allows 60 per cent purification in aerators. Hope to lower cost of treatment by the combined process.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Water Softeners in Boiler Practice. W. Scherr. Water and Water Eng., **25:** 297, 335-6, September 20, 1923. Lime soda treatment requires 6 to 8 hours unless warmed to 50–60°C. Efficiency of filter must be watched, and concentration of soluble salts regulated by blowing off. Free $Ca(OH)_2$ is objectionable, but a slight excess of Na_2CO_3 is helpful in acting on Mg. In thermochemical processes it is necessary to prevent re-absorption of gases, especially if some softened water is added to condenser water. Zeolite softening requires

clear water. Distillation is expensive and distilled H_2O likely to corrode metals if absorption of gases is allowed to take place.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Water Supply of the Central Argentine Railway. J. COCHRAN. Water and Water Eng., **25**: 328–9, September 20, 1923. Supply is derived from area of Old Pampean sea, formerly connected with the Atlantic: contains much mineral matter, and is bad boiler water. Fine mud of Parana river is very troublesome and hard to get rid of. $MgSO_4$ and NaCl cause trouble.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Biochemical Factors in Modern Water Purification. GILBERT J. FOWLER. Water and Water Eng., **25**: 359, October 20, 1923. (Paper read at Mysore Eng. Assn. Conference, Bangalore, 1923.) Aeration of waters is advocated as means of oxidizing food material and keeping down increase of bacteria, possibly inhibiting growth of algae and removing volatile impurities. Efficiency of French non-submerged filters has not received deserved attention. Similarity in principle between water and sewage purification processes emphasized. Aeration alone, in presence of a suitable nidus, or "scaffold," has been shown to be an effective process in the case of the Yangtsze river and the author's activated silt process. (Fowler and Deo, J. Indian Inst. Sci. **2**: p. 9.) Oxidation of organic matter in wells by $KMnO_4$ and removal of bacterial food has been shown to be effective in preventing multiplication of bacteria.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Silt Separation at Diversion Works. F. V. ELSDEN. Water and Water Eng., **25**: 368 and 411, October 20 and November 20, 1923. Paper based on Egyptian conditions and the knowledge that (1) in all silt laden streams the heaviest silt is that which is rolled along bed of stream, and (2) quantity and coarseness of silt carried by the stream increase from the top downward. "Skimming regulators" are recommended. These are designed to avoid disturbance and silt-lifting eddies and restrain sandy silts and other coarse material from getting into conduits and other water passages.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Institute for Water-, Soil-, and Air-Hygiene at Berlin-Dahlem. DR. F. WILHELMI. Illustrierte Zeitung, **161**: 184, September 6, 1923. A general illustrated article on the work of this famous Institute.—*Jack J. Hinman, Jr.*

Purification of Drinking Water. C. A. GRAU. Semana Medica, **1**: 1189, June 28, 1923; J. Am. Med. Assn., **81**: 2068, December 15, 1923. Prepare solutions as follows: Solution A.: potassium iodide, 2 grams; iodine: 8 grams; alcohol, 90 cc.; glycerol, 32 cc. solution B: sodium thiosulphate, 15 grams; alcohol, 40 cc.; glycerol, 5 cc.; water, 45 cc. To 1 liter of water to be treated add 5 drops solution A. Shake. After 20 minutes, add 5 drops solution B and mix. Water is ready for use. Avoid wooden vessels since wood absorbs iodine. Method was designed especially for rural schools where suitable water did not exist.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Water and Health. ANON. Chicago Dept. of Health, Monthly Bulletin, **17:** (n.s.); October 20, 1923. General review of Chicago's water supply experience. In 1891, Chicago had 175 deaths from typhoid per 100,000 population; in 1922, Chicago had 1 death from typhoid per 100,000. Chlorination started in 1912, but all water was not chlorinated until 1918. Average use is 0.3–0.4 p.p.m. Cl. 6 p.p.m. Cl will not kill *B. subtilis*.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Significance of B. Coli in Water in Relation to Health. W. H. FROST, Nation's Health, **5:** 527, August, 1923. A general paper—*Jack J. Hinman, Jr.*

Method of Boiling Drinking Water Used in Camp. C. I. WOOD. U. S. Naval Med. Bull., **19:** 166, August, 1923. Illustrated article on installation at Santiago, Dominican Republic, of 4 gasoline drums set on railroad rail and brick support above furnace. Furnace chimney with steam escape pipe for each drum. Boiled water run to metal storage tank. Intend to insert Darnall filter in line between boilers and tank to get rid of silt.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Conservation and Control of Water Resources. J. PARRY. Water and Water Eng., **25:** 339, September 20, 1923. Plea for National Trust, to control water shed areas and sources of water supply (in Great Britain). Most of the best areas of sufficient rainfall and elevation have been taken up as virtual monopolies by large municipalities and companies. The underground water situation is also unsatisfactory.—*Jack J. Hinman, Jr.*

The Denis-Foraky Teleclinograph. ANON. Water and Water Eng., **25:** 336–9, September 20, 1923. Illustrated article describing an apparatus for determination of deviation of bore holes.—*Jack J. Hinman, Jr.*

Absorption of Atmospheric Cases by Water. J. H. COSTE. Analyst, **48:** 433–435, 1923. Chem and Ind. **42:** 1244A, December 28, 1923. Graph showing volumes of oxygen and nitrogen at normal temperature and pressure dissolved by 1 litre of water of any salinity from 0 to 20 grams of chlorions per kilogram of water. (W. P. S.)—*A. M. Buswell.*

Schlagdenhaufen's Reaction for Magnesium Salts: Application to Waters. G. MEILLERE. Ann. Falsif., **16:** 410–411, 1923. Chem. and Ind. **42:** 1244A, December 28, 1923. Test depends on formation of a brown precipitate when solution containing a magnesium salt is treated with alkaline hypoiodite. Ten cubic centimeters of the water under examination is mixed with 2 cc. of 20 per cent potassium iodide solution, and sodium hypobromite solution is added, drop by drop, until the intensity of the color ceases to increase. Excess of hypobromite should be avoided. Color is at a maximum within about 15 mins., and then fades gradually. Comparison with colorations produced by known amounts of magnesium affords means of determining quantity of the metal present. Waters containing carbon dioxide or bicarbonates must be treated with hydrochloric acid and evaporated before test is applied (W. P. S.).—*A. M. Buswell.*

A New Type of Deep Well Pump. ANON. Contract Record, 37: 781-2, 1923. "Axiflo" pump, in which all right angled drives have been eliminated, a form of propellor being employed in place of conventional impellor, is described and illustrated. Advantages claimed are: high efficiency and low operating and installation costs; continuous flow, free from pulsations and noise; very simple and compact, often saving cost of new wells by obtaining more water from existing small well in which larger centrifugal pump cannot be employed.—*R. E. Thompson.*

Treatment of Waters Containing Alkaline Bicarbonates. E. D. GRANT, AND BECCO ENGINEERING AND CHEMICAL CO. E. P. 207, 696, 22.11.22. Chem. Ind., 43: 6, B.112, Feb. 8, 1924. Sufficient calcium sulfate and calcium hydroxide are added to transform the alkali bicarbonate, or any desired proportion thereof, into alkali sulfate, with simultaneous precipitation of lime from the initially formed calcium bicarbonate. The sulfate and hydroxide of lime are preferably added in form of powder, and either may be in excess, according to purpose for which water is to be used (J. H. W.).—*A. M. Buswell.*

Annual Report of the Division of Water and Sewage Disposal. (Columbus, Ohio). City Bulletin, 8: 14-25, April 5, 1924. Average for year, 23.5 million gallons softened and filtered per day, equivalent to 92 gallons per capita per day. Raw water average hardness 265 parts per million. Softened water 95 parts per million. "To reduce the hardness of the water from an average of 265 per million to 95 parts per million 3,246 tons of soda-ash and 5,594 tons of lime were required. The price paid for soda-ash was $30.95 per ton and the price paid for the lime was $10.26 per ton, making the total cost for soda-ash $110,464, and the total cost for lime $59,408; or the cost of the lime and soda-ash per one million gallons of water softened amounted to $19.47." Turbidity reduced from 90 parts per million to 0; color from 24 parts per million to 2. Typhoid rate 4.2 per 100,000; resident typhoid rate 1.2 per 100,000. Further information is furnished on carbonation of softened water; washed fuel gases are found suitable since SO_2 is highly soluble and CO_2, relatively insoluble. Cemented sand diffuser copied from the cemented gravel Toronto filters was used. "The conclusion on results obtained in agitation experiments are given in the following paragraphs. (1) Results of plant operation and laboratory experiments indicate that velocities of 0.3 foot per second do not provide sufficient agitation for the treatment of turbid water or for water softening, but that the velocities do not need to exceed 0.6 foot per second. (2) Coagulation results obtained on turbid water at velocities of 0.6 foot per second can be obtained at lower velocities only by adding an excess amount of coagulant. (3) A short mixing period of 20 to 30 minutes at 0.6 foot per second velocities is more effective than a mixing period of 1½ hours at 0.3 foot per second velocity. (4) Mechanical agitators are less expensive to build, more compact, obviate the necessity of lifting water the extra two or three feet necessary to pass through baffled mixing tanks, and provide greater flexibility and accessibility." Detailed sheets of operation and analytical data are given. The Division of Sewage Disposal takes up four pages for its report; pumping and operating data are given.—*A. M. Buswell.*

Pure Water Supplies. (Extract) SIR ALEXANDER HOUSTON. Plumber and Journal of Heating, **45**: 539, 316, December 1, 1923. Review of water supplies of England. Water of almost virgin purity furnished to about one-ninth of population. Deep wells and springs needing no treatment, unless softening or iron removal, supply two-ninths. Water requiring treatment is used by remainder of inhabitants excluding those in London.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Status of Texas Water Supplies. V. M. EHLERS. Texas State Journ. of Medicine, **19**: 3, 187, July, 1923. Of 76 surface supplies, 25 are filtered, 29 are given sedimentation treatment, 18 chlorinated, 14 raw; 263 ground water supplies, 19 chlorinated; 12 mixed supplies, 3 filtered, 5 chlorinated, 4 raw water supplies.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Preliminary Data Required for the Intelligent Design of a Water Purification Plant. C. ARTHUR BROWN. Lecture delivered to Operators School, Waco, Tex. Graphic curves of past, present and deductive future of Post Office receipts, bank deposits, water department gross income, population, and water consumption, are used to determine probable future consumption and size of plant required. All available sources of water studied taking cognizance of quality and quantity and engineering difficulties in utilization. Location of intakes and purification plant; cost and maintenance, and public opinion are discussed.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Rivers Pollution and Fisheries. Report by Standing Committee on Rivers Pollution, Ministry of Agriculture and Fisheries of Great Britain. Report discusses bearing of sewage on fish life, reviewing briefly developments of sewage disposal. Research experiments to determine effect of various concentrations of polluting materials on fish.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Power Plant Auxiliaries and Their Relation to Heat Balance. A. L. PENNIMAN, JR. Presented at Convention of A. I. E. E., Phila., Pa., February 4–8, 1924. In central steam plants, efforts to increase over-all economy and ease of operation are responsible for the use of motor-driven auxiliaries receiving power from auxiliary turbo-generators, the exhaust from which is used for heating feed water. Greater economy is possible by bleeding steam from low pressure stages of main unit to heat feed water. Considerable heat is reclaimed allowing a smaller condenser and performance of main turbine is improved due to relieving the congestion of steam in low-pressure stages.—*A. W. Blohm.*

Citrate Utilization by Members of the Colon-Aerogenes Group and Their Differential Characteristics. STEWART A. KOSER. Jour. Bacteriology, **9**: 1, 59, January, 1924. B. coli of fecal origin can be distinguished from soil organisms through inability of fecal bacteria to multiply in media containing citrate as sole source of carbon; whereas soil bacteria grow luxuriantly therein. At least twenty-three strains of soil organisms which would be considered

positive fecal coli from results of methyl red test, may be proven non-fecal through their ability to grow and multiply in media containing 2 grams sodium citrate per litre as only source of carbon. Presence of these strains in soil and their absence from fecal specimens would indicate that sometimes the methyl red confirmation has been responsible for reporting of presence of fecal bacteria, when only soil bacteria were present. The ability to utilize citrates should prove a valuable method of identifying more accurately fecal from non-fecal bacteria. [Perhaps one or more or Mr. Koser's "23 varieties" exist in certain cases on the surface film or deposit inside of water mains, only to be torn loose upon opening fire plugs, etc. Samples collected after flushings or sudden draughts are frequently reported by routine test to contain fecal B. coli, although samples for weeks, or even months, prior to flushing showed consistently absence of colon-aerogenes group.—ABSTR.]—*Linn H. Enslow.*

Corrosion of Steel in Contact with Copper by Natural Waters. W. G. WHITMAN AND R. P. RUSSELL, Ind. Eng. Chem., **16**: 3, 276, March, 1924. Corrosion of steel in natural waters is increased wherever it is in contact with other metals more "noble" than itself. Rate of corrosion is dependent upon rate of hydrogen depolarization by dissolved oxygen. Accelerated corrosion of steel in contact with copper is due to increased area available for reaction between dissolved oxygen and hydrogen protective film. As conductivity of solution increases, the copper (or other metal more "noble" than steel) will act as depolarizing surface over increasing distances from the steel, thereby resulting in intensified corrosion. Experimental work indicated a rapid rate of corrosion during first few days. After fourth day, rate had fallen to a constant value which then held for remainder of test. Local corrosion is increased and severe pitting results, where steel is in contact with more "noble" metals. This can be attributed to increased "effective" surface for hydrogen-depolarization.—*Linn H. Enslow.*

Soluble Aluminum—Hematoxylin Test for, in Filtered Water. WM. D. HATFIELD. Ind. Eng. Chem., **16**: 3, 233, March, 1924. Satisfactory tests for presence of soluble aluminum in waters through use of hematoxylin may be had only within comparatively narrow zone of hydrogen-ion concentration; viz., pH 8.0–8.5. The hematoxylin-alumina color compound will not form below pH 6.0: above pH 8.5, the color fades rapidly. Between pH 6.5 and 7.5 a relatively permanent, but slow forming, color develops. Waters adjusted to pH 8.0 to 8.5, if containing soluble aluminum, will produce a blue color, which upon acidification with 30 per cent acetic acid, changes to a purple. The excess hematoxylin present changes to yellow, thereby presenting variations from yellow through brown to purple, depending upon quantity of aluminum present and excess of indicator. The improved procedure calls for buffering 50 ml. water with 1 ml. saturated ammonium carbonate (aqueous) solution, to obtain a pH of 8.2±. Add 1 ml. of 0.1 per cent (aqueous) hematoxylin solution, mix, and allow 15 minutes contact for color development. Acidify with 1 ml. 30 per cent acetic acid and compare with standards of known aluminum content treated in like manner.—*Linn. H. Enslow.*

Phenol-Chlorine Water Pollution. EDW. F. KOHMAN. Ind. Eng. Chem., 15: 5, 518, May, 1923. A 500-ton capacity coke plant, discharging wastes into lake which feeds river of 520 to 820 cubic feet second average flow, caused trouble at a canning plant 6.5 miles distant. Chlorinated city water used in cannery imparted medicinal taste to canned peas, pears, etc. Water containing phenol (1 part to 750 million) after chlorination produced more pronounced and altogether different taste than was obtained by dissolving prepared chlorphenols in higher concentrations (1 part in 1–50 millions). Phenol in greater concentration than 1 in 50 millions after chlorination produces taste like that of solutions of prepared chlor-phenols. A *small excess* chlorine completely destroys phenolic taste and odor at above dilutions.—*Linn H. Enslow.*

Bacteria in Tannery Soak Waters—Effect of Salts Upon Counts. J. A. WILSON AND C. J. VOLLMAR. Ind. Eng. Chem., 16: 4, 367, April, 1924. Standard nutrient agar (pH 6.9 to 7.1), to which 0.05 mole NaCl per liter was added, produced eighteen times the number of colonies obtained on same medium unsalted, when each was plated out with tannery soak liquors. Other salts produced similar results. KCl (0.1 mole); Na_2SO_3 or $CaCl_2$ (0.025 mole) per liter compared favorably with 0.05 mole NaCl per liter. Increase in concentration over the figures given above for each salt resulted in rapidly decreased counts. Apparently, small amounts of salt will increase dispersion of bacteria, whereas larger amounts will result in agglutination. Increasing period of incubation above 24 hours gave no increase in number of colonies per plate. Count is also dependent upon degree of agitation. Vigorous shaking for five minutes produced a count eight times that from a shaking of only 15 seconds.—*Linn H. Enslow.*

Corrosion of Steel Immersed in Water—Effect of Alkaline Solution on. F. N. SPELLER AND C. R. TEXTER. Ind. Eng. Chem., 16: 4, 393. April, 1924. In clean steel pipe, initial rate of corrosion is nearly independent of alkalinity of water within certain limits; but at 150°F., rate rapidly decreases for an hour or so until a protective film of ferric-hydroxide has been built up and a state of equilibrium established. At this point, alkalinity has an inhibiting effect upon corrosion. The film formation is apparently of greater importance than the decreased hydrogen-ion concentration. The hydroxyl-ion is the important factor in protecting steel against corrosion, and not the deposition of a protective coating of calcium, etc. as has been previously assumed. At 150°F., 0.12 grams per litter (7 grains per gallon) of NaOH reduced rate of corrosion practically as satisfactorily as higher concentrations. The protective ferric-hydroxide film will not last long when water without alkali is again run through the pipe.—*Linn H. Enslow.*

Quantitative Determination of Iron in Iron Removal Plants. J. H. LINSCHOTEN. Water en Gas, 8: 195, 1924. Arrangement of an experimental iron-removal plant is briefly described. Water passes first through coke trickler; then through preliminary filter; it is then distributed between two final filters, one of coarse, the other of fine sand. For control purposes, samples are taken of: (1) raw water, (2) coke trickler effluent, (3) preliminary

filter effluent, (4) coarse sand final filter effluent, and (5) fine sand final filter effluent. Determinations are made of CO_2, HCO_3^-, Fe^{++}, Mn^{++}, both locally and at Central Laboratory (excepting that Mn is not locally determined). Local iron determinations were formerly carried out as follows: add N × 0.1 NaOH; shake in bottle to oxidize ferrous iron to ferric; add N × 0.1 HCl to neutralize both natural alkalinity and NaOH added; measure volume; to 100 cc. add 1 cc. dilute (1:5) HCl, to bring all iron into solution; determine colorimetrically as usual with KCNS, making comparison standards equally acid with sample. Results are satisfactory except when appreciable amounts of organic matter are present; when this happens, a miniature-scale laboratory method has been found preferable: 10 cc. of water are cautiously evaporated to dryness in small porcelain dish with HCl and $KClO_3$; residue is taken up with 1 cc. dilute HCl and distilled water, transferred to small flat-bottomed graduated tube, treated with 1 cc. KCNS, made up to 10 cc., and compared with standards in similar tubes, similarly acidified. In this way interference by protective colloids is avoided. Results given show method to be satisfactory. It is recommended for adoption in all cases. Comparative tables exhibit clearly results obtained on numerous samples by the different methods.—*A. Massink.*

NEW BOOKS

Surveillance des Eaux Pendant L' Année, 1922. M. F. Dienert. This annual publication deals with inspection and supervision of sources, collection, transportation and purification of Paris water supply. Present volume gives rather complete data on rainfall, temperature, electrical resistivity, turbidity, biology, and chlorination. Sanitary surveys and bacteriological findings are also reported. A new filter plant at Ivry was put into operation during 1922. Water is sand filtered and subjected to chloramine treatment. The chlorine addition averaged 0.27 mg. per liter during 1922. The ratio of ammonia to chlorine added, as chloramine was formed, constant at 1 to 40. At purification works of St. Maur, filtration and javellization at rate of 0.35–0.65 p.p.m. of chlorine are used. This kills B. coli and pathogens, but allows sporulating species to live. Water, on its arrival at distribution reservoirs, is completely dechlorinated, in some cases by several treatments, with thiosulfate. As an added protective measure, an aquarium is maintained at the reservoirs, since fish are extraordinarily sensitive to free chlorine. In tracing sources of supply of swamps of Larchant, fluoresceine was used as an indicator. In the dry season, this dye, put into the swamp waters, was soon found in nearby water supplies, some appearing 8 kilometers away in 9 days. The greater part of report deals with bacteriological analysis of water. The chief of the department raises several questions as to purpose and importance of such analyses, especially with reference to pathogen detection. Media and methods in use in Paris are described, and characterizations of the more important colon bacteria are given in some detail. Requirements of a good filtered water supply are outlined.—*A. M. Buswell.*

The Sanitation of Bath Houses. Gerhard, Wm. P. New York; Wm. T. Comstock Co. 16 pp. $0.60. Reviewed in Municipal Engineering, 72: 694, 1923.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

London Water Supply: Annual Report, 1922-3. Municipal Engineering, 72: 697, 1923. Surveyor 64: 506, 1923. Board supplied during the year 88,881.0 million gallons direct to consumer and 683.1 million gallons to other water authorities; daily averages of 241.64 and 1.87 million gallons respectively. The per capita consumption daily was 35.07 gallons.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Analyse et Essais des Materiaux de Construction. Chimie et Physique Appliquées aux Travaux Publiques. J. MALLETTE, chef du laboratorie de chimie a l'Ecole nationale des Ponts et Chausees, 2nd edition, 14 × 22 cm., 916 pages, 189 fig., Dunod, editeur, Paris, 54 francs.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Wasserversorgung und Abwasserbeseitigung. WILHELM CLAR. Potsdam and Leipzig; Bonnez und Hachfeld. M. 3.25. 24 pp. From Chem. Abst., 16: 2566, August 10, 1922.—*R. E. Thompson.*

Grundlagen der Wasserwirtschaft. WILH. HALBFASZ. Berlin: Gebr. Borntrager, M 32. 154 pp. Reviewed in Gas u. Wasserfach, 65: 13, 1922. From Chem. Abst. 16: 2566, August 10, 1922.—*R. E. Thompson.*

Erdsalzgehalt des Trinkwassers und Kariesfrequenz in der Schweiz. WALTER PAUL. Zurich: Berichthaus. 39 pp. From Chem. Abst., 16: 2566, August 10, 1922.—*R. E. Thompson.*

Kalender fur das Gas- und Wasserfach. E. SCHILLING AND G. THIEM. 2 parts. München: Oldenbourg. In pocket form, M. 50. Reviewed in Gesundh. Ing., 45: 192, 1922. From Chem. Abst., 16: 2597, August 10, 1922.—*R. E. Thompson.*

Outline of Ground-Water Hydrology with Denfiitions. OSCAR E. MEINZER. U. S. Geological Survey, Water Supply Paper 494, 1923. This paper gives a very complete outline, with definitions, of the numerous terms employed in ground water hydrology, including atmospheric water, surface water and subsurface water. Diagrams and maps illustrate many of the terms.—*A. W. Blohm.*

The water works pumping station of the City of Allentown, Pa., is described in an illustrated leaflet issued by the De Laval Steam Turbine Company, of Trenton, N. J. The water supply for the 85,000 inhabitants is taken from two springs, one located near the pumping station and the other at a distance of 5 miles, is supplied to 19,000 connections at a single family rate of $3.75 net per year. The pressure varies from 40 to 100 pounds. The principal pumping equipment consists of two centrifugal pumps designed to be driven either by steam turbine or by an electric motor using purchased electric power, the units being mounted upon an elevated platform above flood level, so that the pumps can continue to operate in case the steam supply fails due to flooding of the pumping station.

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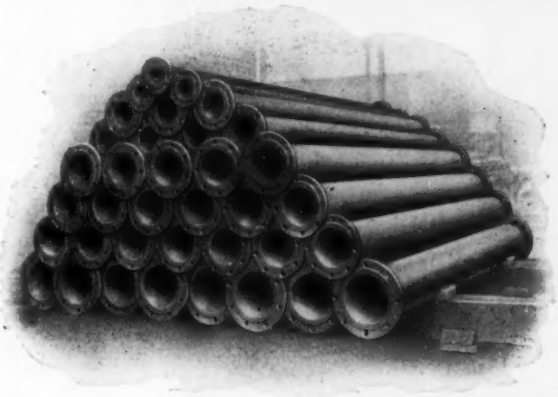

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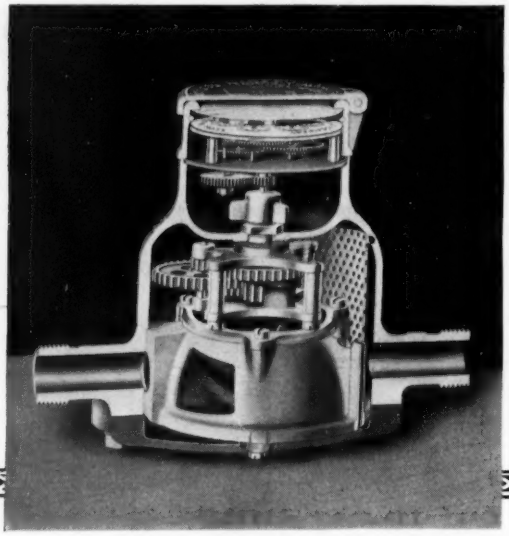

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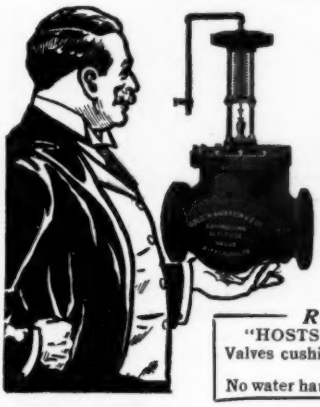


We have enlightened many a water user in municipalities, in industrial plants and on railroads, as to the **adaptability** of these Golden-Anderson Valves, and as to their function of SAVING, and of eliminating troubles.

For automatically maintaining Uniform Stage of Water in Tank, Reservoir or Standpipes. Doing away with the annoyance of Freezing and Float Fixtures inside or outside of Tanks.

"Three Ways of Closing These Valves:"

1st—Automatically, by water
2nd—By Electricity, if desired
3rd—By Hand

May also be arranged to automatically close when a break occurs in the mains. When necessary they may be so connected as to "work both ways" on a single line of pipe.

No valves or fixtures inside or outside.

Sizes to 30 in.

Remember!
"HOSTS OF REFERENCES"
Valves cushioned at all times by air and water
No water hammer or bursting mains

"Made with stop starter attachment for centrifugal pumps"

GOLDEN-ANDERSON
Automatic Cushioned Water Regulating Valves

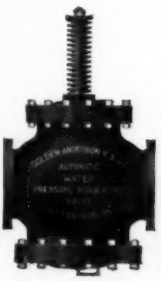
for high or low pressure service are a *necessity* for modern water works and railroads.

Positive in action and perfectly cushioned both in opening and closing.

Will maintain a constant pressure regardless of the volume of the initial flow.

When fitted with electrical attachment valve can be instantly opened to full area from any number of distant points, thus insuring full pressure in case of fire, etc.

Sizes to 30 in.



For Fire Service **GOLDEN-ANDERSON**
Cushioned Electric Water Service Valves

No waste of current, as it is only on solenoid a few seconds on either opening or closing of valve.

May be closed and opened from remote points electrically; also hand operated.

Air and water cushioned.

No metal-to-metal seats.

Virtually indestructible.

Sizes to 30 in.

GOLDEN-ANDERSON
Cushioned Water Relief Valves
Automatically Relieve Excess Pressure—Prevent Stress, Strain and Bursting Mains

Essentials of a durable economic and reliable relief valve are first class material and workmanship, correct mechanical construction and operation, with no metal-to-metal seats, and perfect air and water cushioning to avoid shock or hammer on the various pressures all of Golden-Anderson Patent Automatic Cushioned Water Relief Valve

Sizes to 30 in.

Angle and Globe Patterns

GOLDEN-ANDERSON
Patent Automatic Double Cushioned Check Valve

Automatically prevents reverse flow of pressure.

Perfectly cushioned to prevent shock or hammer.

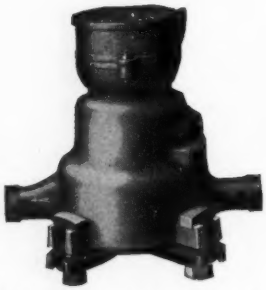
Especially adapted for water works to prevent disastrous reverse flow of pressure due to pumps stopping.

Arranged so that quick or slow operating may be obtained.

Sizes to 30 in.
Angle or Globe

Golden-Anderson Valve Specialty Co., 1215 Fulton Bldg., Pittsburgh, Pa.

WATER METERS



ARCTIC—*a frost-bottom meter for domestic services.*

KEYSTONE-COMPOUND—*for services requiring accurate measurement of small as well as large volumes of water.*

EUREKA—*a current meter for large and rapidly flowing volumes of water.*

KEYSTONE—*an all bronze meter for domestic services.*

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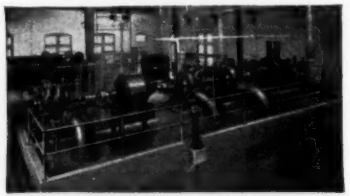
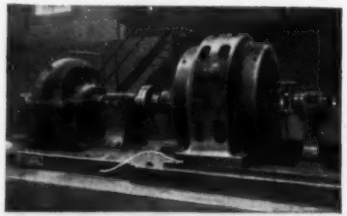


Allentown, Pa.; turbine driven 12 m.g.d. unit and motor driven 7 m.g.d. unit, 273 ft. head

Kansas City, Kans.; motor driven 25 m.g.d., 324 ft. head



Montreal, Quebec; motor driven 30 Imp. m.g.d., 220 ft. head

Leading American Cities Use

De Laval

Steam Turbine Driven Centrifugal Pumps

More than 150 American municipalities now receive their water supply from De Laval pumping units.

The aggregate capacity of these units exceeds 4 billion gallons per day, which is sufficient to meet the average water requirements of more than a quarter of the total population of the United States.

The general adoption of De Laval Geared Steam Turbine Driven Centrifugal Pumps is due to the great economies which they effect in fuel or electric power, in building costs, and in attendance and upkeep expenses. They handle water at the lowest overall cost.

Our engineers would take pleasure in studying your requirements and in submitting facts and figures for your consideration. Ask for Special Publication W-94.

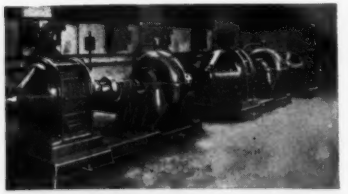
De Laval

Steam Turbine Co., Trenton, N.J.

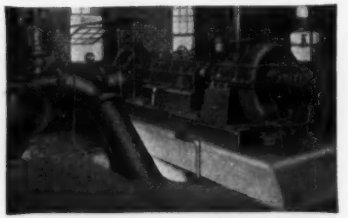
LOCAL OFFICES: Atlanta Birmingham Boston Charlotte Chicago Cleveland Denver Duluth Havana Honolulu Houston Indianapolis Kansas City Los Angeles Missoula Montreal New York New Orleans Philadelphia Pittsburgh Salt Lake City San Francisco Seattle Toronto Vancouver

377

Atlanta, Ga.; one of five turbine driven units, 30 m.g.d., each, 255 ft. head.



Indianapolis Sanitary District; 10,500 g.p.m. each, 28 ft. head.



Greensboro, N. C.; turbine driven 5 m.g.d., 176 ft. head.

THE A. P. SMITH MANUFACTURING COMPANY
EAST ORANGE **NEW JERSEY**

Manufacturers of Water Works Specialties as Follows:

Smith Tapping Machines for making connections 2″ to 36″ inclusive, without shutting off the pressure.

Valve Inserting Machines, for inserting Valves, 4″ to 20″ inclusive, in existing lines of pipe without shutting off the pressure. With this Machine Valves can be installed in front of Hydrants.

Corporation Tapping Machine, for inserting Cocks under pressure. Light, durable and absolutely guaranteed.

Pipe Cutting Machines of various sizes for cutting 4″ to 54″ pipe.

Also manufacturers of High Grade Water Gates, Fire Hydrants, for both low and high pressure service, Brass Goods of every description and various other Water Works Specialties.

Send for circulars

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One does not have to be an expert mathematician to figure out that a clogged water main calls for a stronger pressure and that in turn calls for more coal—and literally burning up money. We can show you how to get dollar for dollar value out of every ton of coal. We can show you how to clean the water mains quickly and cheaply. Send us your address—that's all we ask of you.

National Water Main Cleaning Co.
NEW YORK CITY

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More than a million and a half meters in service proclaim the pre-eminence of the Trident meter.

That success could be achieved and was achieved by one factor alone,—*the worth of every Trident made!*

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"GLAUBER" BRASS GOODS

NEVER FAIL TO MAKE A GOOD IMPRESSION - ONE THAT LASTS

GLAUBER BRASS MFG. CO.

Cleveland, Ohio

NASH TYPE K WATER METERS

WELL DESIGNED
CAREFULLY BUILT
ACCURATE
SUBSTANTIAL
SATISFACTORY

We have been making disc meters for over thirty-five years. Every improvement that experience and experiment have proved to be valuable we have incorporated in our NASH Type K. We are confident that there is no better disc meter made.

WITH OR WITHOUT FROST PROTECTION FEATURE

Our patented breakable flange washer is an efficient and practical device for protecting the working parts of the meter in case of freezing. We recommend in general NASH Type K meters fitted with the frost washers, but we can furnish a "Dixie" style without them for locations where frost damage is not anticipated.

NASH Type K is fully described and illustrated in circular 200. Send your name and address and we will promptly forward you a copy.

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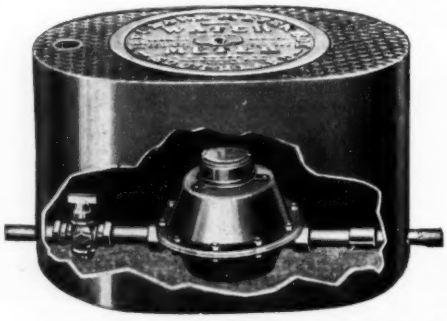
500 METERS READ IN AN 8 HOUR DAY

BY ONE MAN

This is being accomplished by meter readers in every state in the Union.
"But how can I do this" is probably your thought.

By using CLARK METER BOXES

With the fastest operating lock on the market. In 20 seconds ANY MAN can unlock box, read meter and securely lock box.



COMPLETE METER BOXES for use in the South. To unlock, simply insert key, turn ¼ revolution, and lift off lid using key as handle.

COMPLETE METER BOXES for the North.

COVERS AND LIDS for use on box bodies of tile or concrete for all localities.

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that the Association has headquarters in New York City, where the Secretary is ready to be of service to the members when possible. When in the City call at the offce—make it your headquarters. Have your mail directed there if you have not made hotel reservations, and then come to the office for it, or direct the Secretary where you wish it sent. Jot the address and telephone number down in your note book NOW, so as to have it when needed.

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170 Broadway **Telephone Courtland 7718**

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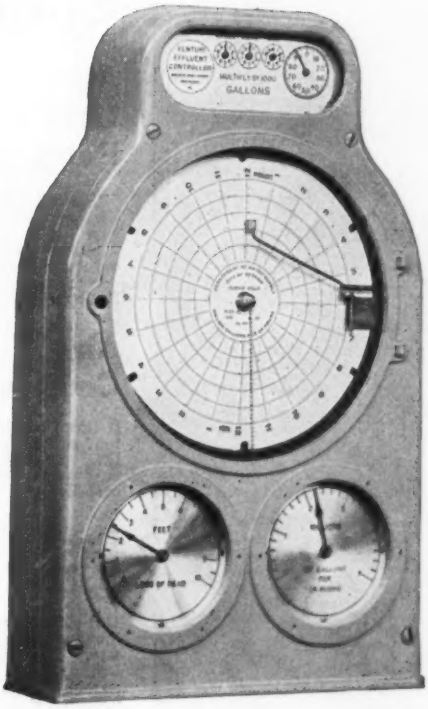

80 Venturi Effluent Controllers control and indicate the Rate of Flow and Loss of Head, record the Loss of Head, and count the total Gallons, making the complete story of the operation of each filter bed continuously available.

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You can depend on the Sullivan air lift to give you maximum capacity from your wells throughout the season. There are no moving parts under water to require cleaning or renewal.

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BY

GEORGE A. JOHNSON

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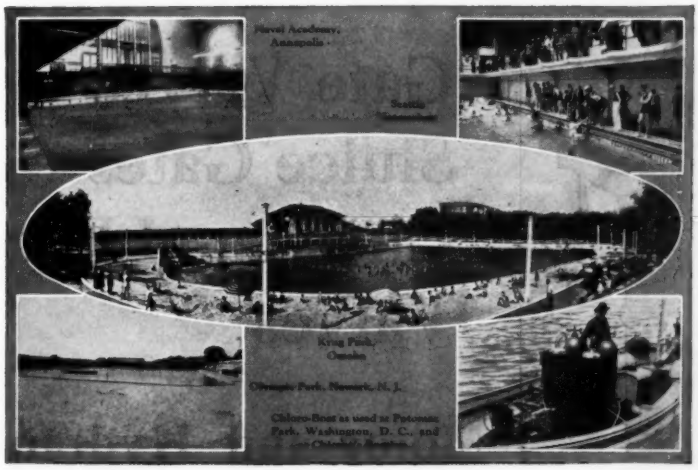

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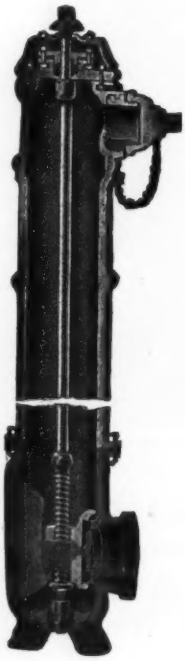

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Fire Hydrants

Simple in Construction

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THE AMERICAN CITY

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BACK NUMBERS

January and March 1920 and 1922

Any members having the earlier numbers of the present volume which they do not care to preserve will confer a favor upon the Association by sending such numbers to the secretary, as an unprecedented call for some of the numbers has almost exhausted the issue in some cases.

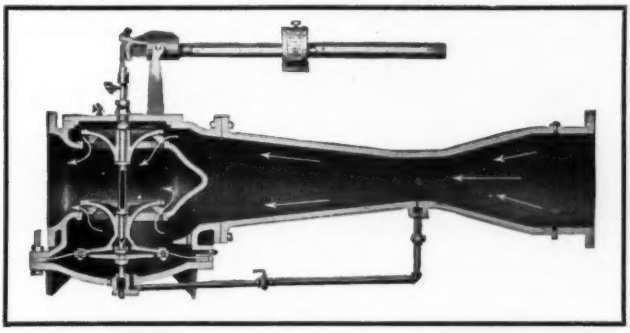
W. M. NIESLEY, Secretary

170 Broadway **New York, N. Y.**

For higher bacterial efficiency on your filter operations---

SIMPLEX

Rate-of-Flow Controllers



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Direct Acting, Keeps its Adjustment, Eliminates Surging and Breaking the Filter Bed, Consequent High Bacterial Efficiency.

For use where Water or other liquids are filtered either by pressure or gravity—especially where the rate of filtration must be kept constant.

Used successfully by ALL the leading Filter Companies and specified by the most prominent Consulting Engineers.

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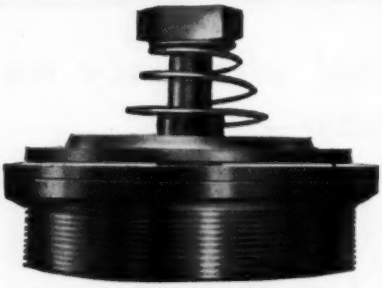
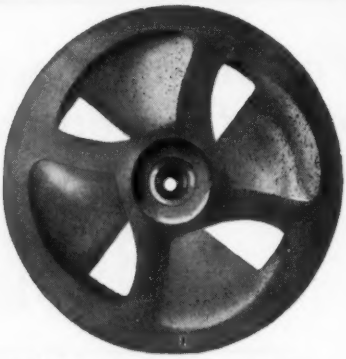


6" Sims Inclined Port Pump Valve, with metal Disc. Pumping heavy gasoline at 250° F.



5" Sims Inclined Port Pump Valve Seat.

SIMS PUMP VALVE COMPANY,

2 Rector St., New York

Makers of

SIMS INCLINED PORT PUMP VALVES

THEY ROTATE THE DISCS

They increase efficiency 7½% to 20%; increase the entire capacity of the pump 20% to 50%, and often over 100%; **reduce slip to a negligible quantity,** and **keep it reduced until the discs are entirely worn out;** eliminate water-hammer, so you can speed up your pump without fear of damage; increase the life of discs 300% to 1000%; give unequalled Vacuum Pump service; **entirely eliminate seat-imprinting; never need to reface discs.** The Sims Valves, **by Rotating the Discs,** will even reface old seat-imprinted discs. See illustrations below.

If in doubt put it up to us to explain how and why **any** or **all** of these results are accomplished. "Tick" (√) off questions below and send to us.

Describe your troubles and let us tell you what we can do for them.

Seat-imprinted disc from Old Style Straight Port Valve Seat.

Same disc after being refaced by use on a Sims Inclined Port Valve.

SIMS PUMP VALVE COMPANY,
2 Rector Street, New York.

Gentlemen:—Please answer the questions "ticked off" below; How does the **Sims Inclined Port Pump Valve:**

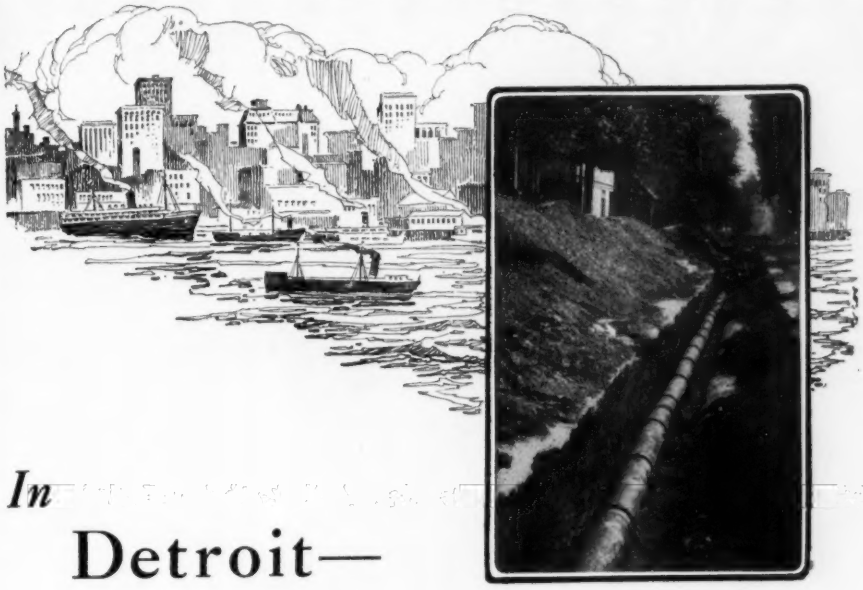
☐ Increase Pump Capacity [20% to 50%]? ☐ Eliminate Valve Water-Hammer?
☐ Decrease Fuel Consumption [7½% to 20%]? ☐ Reduce Slip below ½ of 1%?
☐ Eliminate Seat-Imprinting of disc thereby increasing life of disc 3 to 10 times?
☐ Improve Vacuum Pumps?

I have trouble with, Seat-imprinting ☐, Slip ☐, Valve knock ☐, Capacity ☐, Steam waste ☐.

Name .....

Firm .....

City .....State .....



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Detroit—

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12-inch and 16-inch for water supply

Illustration shows 12-inch line in same trench with Lock-Bar 48-inch steel pipe. Contractors: The Gillespie Contracting Company.

Standard 6-foot lengths convenient to handle —easy to lay

"Universal"—the highest development in cast iron pipe—is ideal for water supply, fire protection and other service where freedom from leakage is essential.

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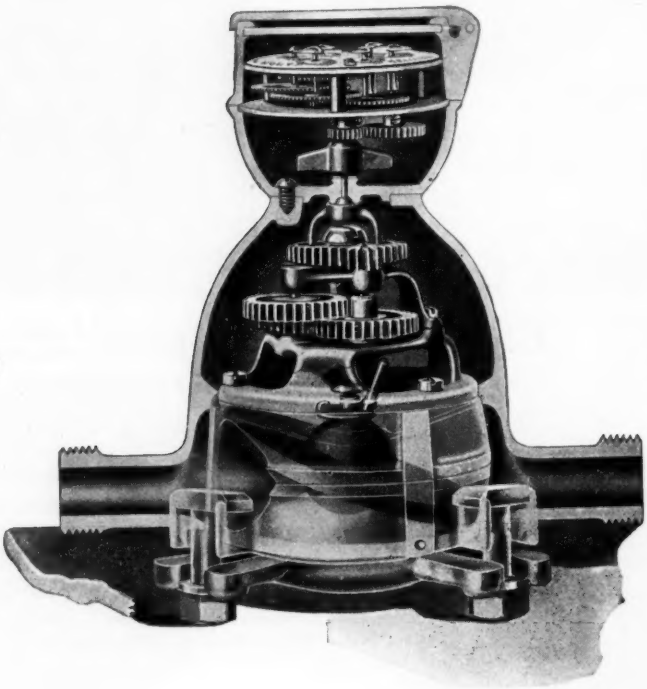
UNIVERSAL CAST IRON PIPE

no bell holes, no lead, no calking

experienced labor unnecessary, wrenches the only tools

"WATCH DOG" WATER METERS

ACCURATE



DURABLE

DISC, CURRENT AND COMPOUND TYPES

Inquiries Solicited

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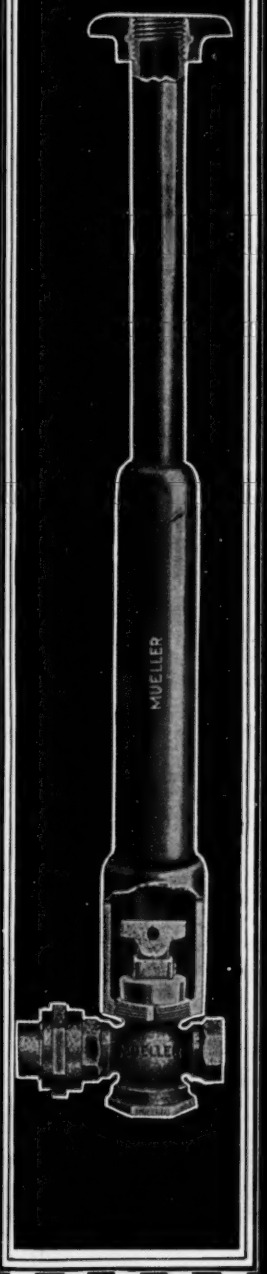

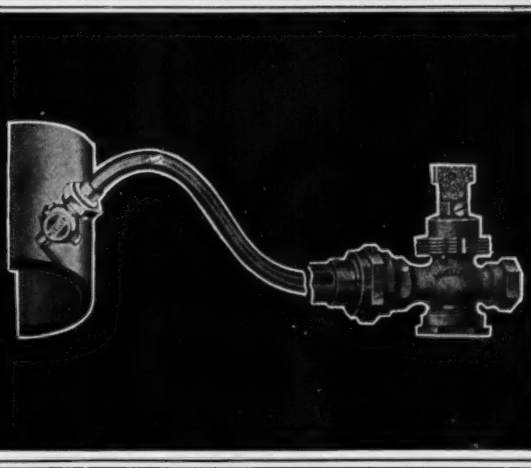

MUELLER

Goose Necks, Curb Cocks Extension Service Boxes

The three items here shown — *MUELLER* Goose Neck No. E-500, *MUELLER* Curb Cock No. E-565, and *MUELLER* Extension Service Box No. E-751—embody the *MUELLER* standards of design and precision in manufacture.

Most Water Companies recognize *MUELLER* leadership—and find that *MUELLER* equipment reduces operating costs and increases dividends.

Write us for detailed information, prices on these and other items, and proof of *MUELLER* efficiency.

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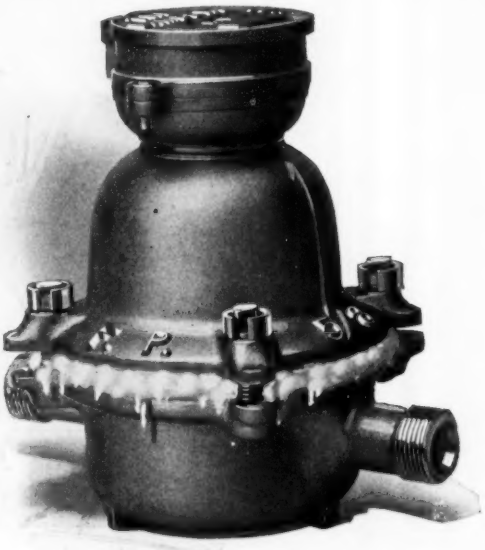
Mueller Metals Co., Pt. Huron, Mich., Makers of Red Tip Brass and Copper Rod and Tubing; Forgings and Castings in Brass, Bronze and Aluminum; also Screw Machined Products.



FROZEN!—but not damaged

Here is an actual photograph of a LAMBERT Frost-Proof Meter which has been frozen to an extent that would put the ordinary meter completely out of commission.

This is made possible by a patented, non-corrosive yielding bolt device which allows the upper and lower casing, disc chamber and gear train to part without damaging the meter in any way. Five minutes' labor the only repair cost.

The expense and annoyance from frozen water meters can be eliminated for all time through the installation of the LAMBERT Frost-proof.

It has been proved that the LAMBERT is the easiest water meter to take apart and put together again as well as the simplest, most reliable and accurate.

If you are interested in other types of meters, we make one for every requirement.

THOMSON METER COMPANY

100-110 BRIDGE STREET BROOKLYN, N. Y.

LAMBERT FROST PROOF METERS

By preventing distortion and early destruction the RUB-STEEL VALVE has earned its right to preference in every reciprocating pump.

VALVE leakage due to twisting, shrinking, dishing and cutting of all-rubber pump valves does not come over night, nor is it detected until pump capacity is badly impaired.

This means at best long power loss and stunted delivery, plus risk of sudden, complete breakdown at any time.

The Voorhees Rub-Steel Valve
"Better than Metal because of the Rubber"
"Better than Rubber because of the Metal"

The steel core or backbone preserves normal true form, equalizes pressure and makes valve tight-closing at all points and when one face is completely worn out, reversal affords a new face that is good as the first.

RUB-STEEL PUMP VALVES

not only make dishing and distortion absolutely impossible, but by complete preservation of the original efficient form, permit reversal. The additional extra life and service from the second side is equal to the extra long life and perfect service from the first.

What you must expect from all-rubber valves:

Dished, warped, seat uneven, premature old age, usable for one face only and early scrapped.

It's only common sense that tripled or greater life at a few cents per valve extra at the start, makes Rub-Steel Valves far cheaper in the long run than buying and placing several sets of all-rubber valves in the same period.

Better, more dependable pump delivery, lessened shutdowns and the saving of time, work and money for pump maintenance will repay your judgment when you standardize on Rub-Steel for every pump valve in the plant.

Four distinct grades of Rub-Steel Valves in a complete range of sizes provide for every make of reciprocating pump and every pressure, temperature and fluid condition.

VOORHEES RUBBER MFG CO
TRADE MARK

Rubber Goods of Ultimate Economy

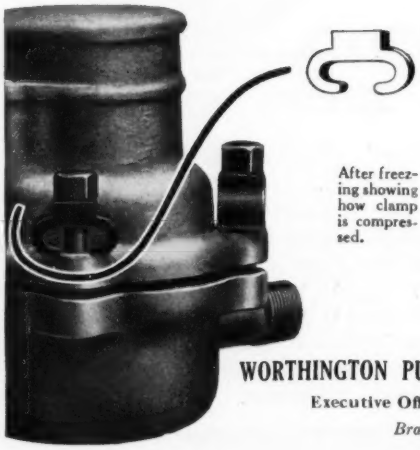
Write for free sample

Main Offices: Jersey City, N. J.; New York, 30 Reade St.; Philadelphia, 242 Chestnut St.; Pittsburgh, 2nd and Ferry Sts.; Kansas City, 2045 Main St.
Pittsburgh, Voorhees Rubber Mfg. Co. of Pittsburgh; Syracuse, Syracuse Supply Co.; Chicago, O. C. Keckley Co.; Memphis, Reichman-Crosby Co.; Beaumont, Norvell-Wilder Hdw. Co.; Wichita, Bridgeport Machine Co.: El Paso, Denver and Salt Lake City, Mine & Smelter Supply Co.; San Francisco and Los Angeles, Pacific Mill & Mine Supply Co., Canada, Voorhees Rubber Mfg. Co. of Canada, Ltd., Montreal.

Frost Protection Revolutionized!

Frost clamp before freezing

Expansion due to freezing taken up by bronze composition clamps which are compressed, without damage to rest of meter.



After freezing showing how clamp is compressed.

These clamps do not break with water hammer or freezing. Under water hammer the clamps constitute a part of the flange and in freezing they yield just to the extent required. Hence on light freezes they can be used two or three times, over and over again.

WORTHINGTON PUMP AND MACHINERY CORPORATION

Executive Offices: 115 Broadway, New York City

Branch Offices in 24 Large Cities

WORTHINGTON

AMERICAN CAST IRON PIPE COMPANY

MANUFACTURERS OF

ACIPCO PIPE-

(1) Is cast iron—it lasts indefinitely.

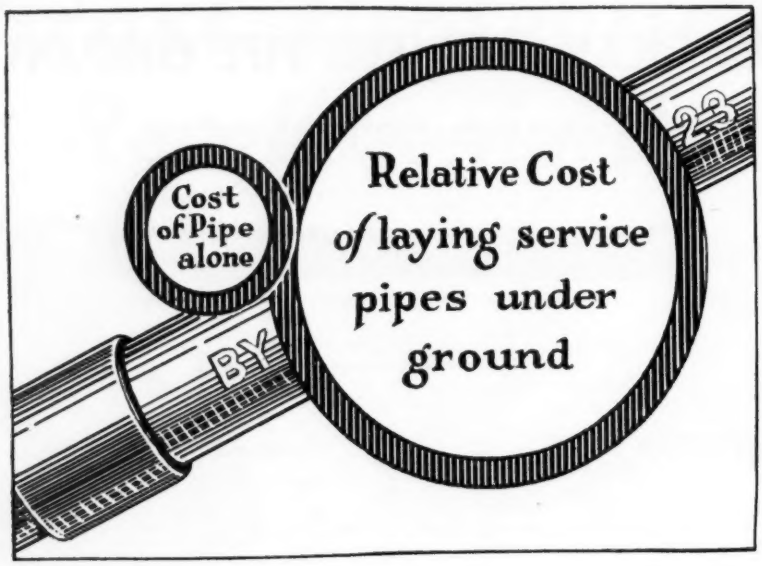
(2) Is made by skilled pipe shop men who are personally interested in making a good product.

(3) Is made in modern plants with efficient equipment and ample financial resources.

(4) Is produced in the heart of great iron and coal fields, where pipe can be manufactured and sold with least cost.

Emergency orders by telephone, telegraph or letter receive prompt attention. Stocks of pipe are carried in principal cities.

AMERICAN CAST IRON PIPE COMPANY
BIRMINGHAM, ALA.
DISTRICT OFFICES IN PRINCIPAL CITIES



A Simple Question of Arithmetic

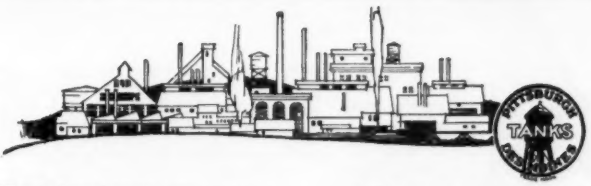
The cost of a length of service pipe is trifling compared with the cost of laying it. In case of failure of the pipe, the loss of water, labor of digging up and renewing, still further multiplies the installation cost.

The lasting quality of the pipe, depending on its rust-resistance, is therefore the first thing to be considered by the majority of experienced water works engineers and superintendents. Hence, the extensive use of Byers pipe for underground water service.

The chemical and physical properties of genuine wrought iron and their bearing on the question of rust-resistance, are interestingly dealt with in Byers Bulletin No. 26 A. Write to A. M. Byers Co., Pittsburgh, Pa., for a free copy.

BYERS PIPE

GENUINE WROUGHT IRON

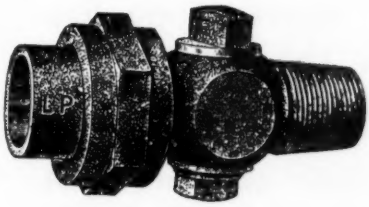


Elevated steel tanks, filter systems, pipe lines bridges, structural steel

Send for our catalogue No. 83. We'd like to be of service

883 CURRY BLDG., PITTSBURGH, PA.

Pittsburgh-Des Moines Steel Co.



We advertise in your journal

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Corporation and curb stops
FLANGED AND OTHERWISE
Inventors of Inverted KEY STOPS

THE FARNAN BRASS WORKS CO.
1104 Center St. CLEVELAND, OHIO
Established 1852

H-ION CONCENTRATION OF WATER

RAW—BOILER—DRINKING

Determinations may be easily and quickly made by using the

LAMOTTE H-ION COMPARATOR SET

Complete and portable, for field and laboratory use.
No additional equipment or reagents necessary.
Descriptive pamphlet on request.

Price, complete, $9.10 (delivered)

LaMotte Chemical Products Co.
13 West Saratoga Street **Baltimore, Md., U. S. A.**

MATHIESON Chemicals

CITY officials are assured of prompt deliveries and superior quality when they specify the following Mathieson products.

Liquid Chlorine	for water purification and sewage disinfection, in the special gray cylinders.
Bleaching Powder	high test and stable, for those who prefer it in sanitary operations.
Bicarbonate of Soda	the best obtainable for charging chemical fire extinguishers.
Soda Ash	both light and dense, for water-softening and cleaning purposes.

The MATHIESON ALKALI WORKS Inc.
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Deal Direct with the Manufacturer

Bicarbonate of Soda
Liquid Chlorine-Caustic Soda

EAGLE THISTLE PRODUCTS

Sesquicarbonate of Soda
Bleaching Powder-Soda Ash

THE NEW NILO

The new improved NILO COMPOUND METER now comes equipped with a bronze body. This is a valuable addition to meter service for it eliminates the danger of corrosion and filling up due to the collecting of corrosive matter. Bronze being stronger than iron the gross weight of the meter is less, making it easier to transport, handle and install.

It also has two gate valves which allow the removal of the by-pass meter for cleaning or repairing without shutting off the line.

The controlling valve mechanism of the new NILO COMPOUND METER is self contained and easily detached from the main body casings.

These three improvements make the NILO, a long standing favorite, the unrivaled leader in its field.

UNION WATER METER COMPANY
Incorporated 1868
WORCESTER, MASSACHUSETTS

IMPORTANT

OWING to an unexpectedly large number of new members since the first of January, we have run short of certain numbers of the Journal for the current year. Any members who are not interested in preserving their back numbers for 1920 and 1922 and are willing to return same to the Secretary's office will be conferring a favor upon the Executive Committee and acting to the benefit of the Association.

W. M. NIESLEY, Secretary,
170 Broadway,
New York City.

Installing Steel Pipe City Streets?

Its **capacity** is equal to that of **NEW** cast iron pipe. And it never grows less as does cast iron. Its smooth interior (absence of rivets except at circumferential joints) develops **lower frictional** resistance than riveted pipe.

Above all, LOCK BAR Steel Pipe is SAFE for High Pressures. The longitudinal joint is **as strong as the plate itself**—100% efficient, compared to the 70% joint-strength of double-riveted steel pipe.

And Lock-Bar Pipe LASTS. Its smooth, heavy, even coating, into which it is vertically double-dipped (and vertically cooled) fully protects it from deterioration and electrolysis. Properly installed, these factors stand for service!

Think it over. There is no reason why your Water Works should install heavy, expensive pipe when you can secure the additional advantages of Lock-Bar Steel Pipe.

Upon request we will be glad to send 200-page "Handbook of Pipe" giving fully comparative tables and charts of weights and capacities together with a fund of data, test results, etc. exactly along the lines you want.

EAST JERSEY PIPE CO., 7 Dey St., New York City

LOCK-BAR

Before Closing

STRONG AS THE PLATE ITSELF

THE DORR CLARIFIER

for

WATER SOFTENING

The Dorr Clarifier presents the most modern and economical means of sedimentation in water softening plants. The continuous removal of settled material makes duplicate units unnecessary. The constant detention period insures a uniform high removal of solids and a uniformly thickened sludge suitable for return to the raw water feed or for inexpensive disposal.

The use of a clarifier materially reduces the size of final settling basins and sometimes obviates their use entirely.

The Dorr Company

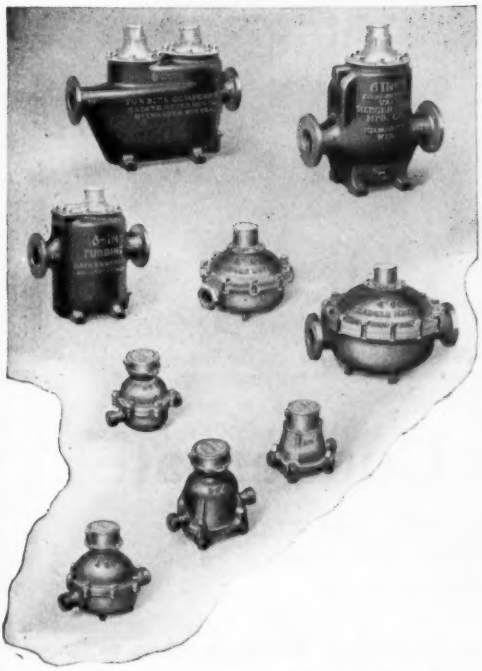
Engineers

Sanitary Engineering Department

247 Park Avenue, New York

Denver Chicago Los Angeles London

A Badger For Every Service



The complete line of Badger Water Meters from the small 5/8″ disc type to the large 6″ Turbine Compound. You will find a type and size Badger Meter for every service.

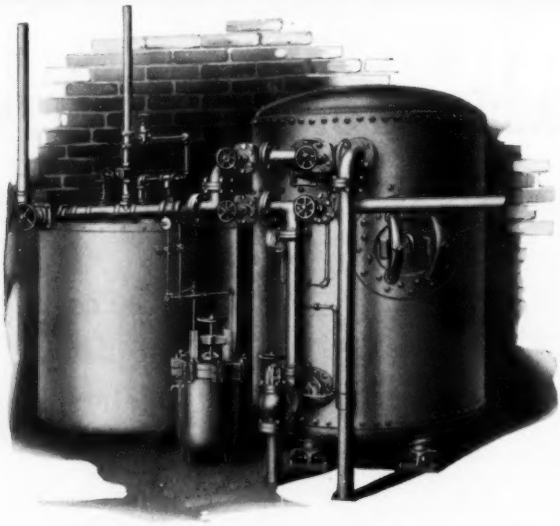
You can conscientiously specify Badger Meters and be assured that they will perform dependably and accurately day-after-day. They are designed by practical water works engineers with years of experience; are made of the highest grade materials obtainable; only skilled workmen figure in the production of Badger Meters. We are always glad to render advice on meter systems and stand ever ready to demonstrate the superiority of Badger Meters—theoretically, structurally, mechanically and practically. Write for more detailed information.

Badger Meter Mfg. Co.

841 30th Street, Milwaukee, Wisconsin

Branches

111 W. Washington Street, Chicago, Ill.
414 Interstate Bldg., Kansas City, Mo.
32 Court Street, Brooklyn, N. Y.
1621-39 Fifteenth Street, Denver, Colo.



Permutit Oil Removal Filters are built in any size to fit any condensate collecting and return system, and any desired working pressure. No special filling materials to be renewed.

Oil-Free Condensate

Reclaim your oily condensate and save those dollars that are now running to waste.

Every 100 gallons of condensate discharged to waste means a direct loss of about 4 pounds of coal. You are actually throwing away fuel.

BUT that is no longer necessary. Permutit Oil Removal Filters will remove absolutely all the oil from condensed steam, and deliver an ideal feed water. It will save its own cost in a few months' time.

Condensed steam contains oil in both suspension and as an emulsion. The ordinary oil filters and those containing so-called "special" filtering mediums, will remove oil in suspension, but they will not take out all the oil that has emulsified. The oily particles are so small that they pass right through such filters.

Permutit Oil Removal Filters are built on a different principle. They are small, compact and simple to operate, and are guaranteed to deliver an ideal boiler feed water supply. Many of the foremost paper manufacturers in the country are equipped with them, and save many tons of fuel annually.

You too can profit by this apparatus. Write for Bulletin 107. Do it today.

The Permutit Company
440 Fourth Ave. New York

Originators of Zeolite Water Softening

LARGEST EXCLUSIVE MAKERS OF WATER CONDITIONING APPARATUS IN THE WORLD

DUAL EXPERIENCE

ASSOCIATED as we are with The United Gas Improvement Company, large operators of gas, electric light and railway properties, we are able to bring to bear on any steam, hydro-electric or gas plant project more than our engineering and construction experience.

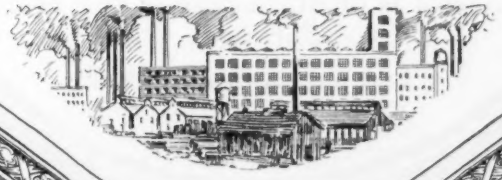
Individually and collectively the paramount thought of our organization is to build so that the result will show the maximum return on the investment. Due to the above association we are able to apply our operating experience to the benefit of their clients.

Perhaps you would like your construction work planned and completed by a concern enjoying these exceptional advantages.

THE U·G·I·CONTRACTING COMPANY

Philadelphia, U. S. A.

FACTORIES .·. POWER PLANTS .·. BRIDGES
GAS PLANTS .·. PUBLIC WORKS



To make dependability more than a byword

To achieve economy in operation

To build so well that durability is an assured fact

These are the ideals on which we build

Character and real worth are the resultant

A VERY INTERESTING CATALOGUE WILL BE SENT THOSE WHO ADDRESS

DAYTON-DOWD CO., Builders of Centrifugal Pumps

Quincy, Illinois - OFFICES IN FORTY-TWO CITIES

Inertol

The Waterproof and Anticorrosive Paint for Water Pipes, Water Reservoirs highly proved as such during 20 years. Inertol is of black colour and ready for use.

Paul Lechler, Inertol Factory
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STANDARD FILTER

SULPHATE OF ALUMINA

FOR WATER PURIFICATION

Lump for solution feed *Special ground for dry feed*

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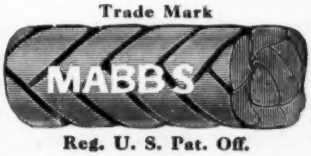
ADDRESS ALL INQUIRIES TO NEAREST OFFICE

Trade Mark



Reg. U. S. Pat. Off.

Mabbs Rawhide Packing
HAS NO EQUAL

For handling any kind of cold liquids such as water, (calcium) brine, oils, air or gases. When properly handled it lasts for years. It never becomes hard or glazed and will never cut or score the rods and plungers. Put up of any size in standard tin pails 5-10-25 and 50 lbs. Price $2.00 per lb.

Try our unsurpassed Chrome and Oak Tanned Cup Leathers

Ask your dealer for it or order direct from

MABBS HYDRAULIC PACKING COMPANY

431 S. DEARBORN STREET (Incorporated 1892) CHICAGO, ILLINOIS

NICHOLAS ENGEL

JOHN FOX & CO.

CAST IRON

WATER & GAS PIPES

FLANGE PIPE

Special Castings, Fire Hydrants, Valves

General Foundry and Machine Work

WOOLWORTH BUILDING 233 BROADWAY

NEW YORK CITY

AMERICA SHOULD PRODUCE ITS OWN RUBBER - H. S. Firestone

Illustrating two fire fighting units equipped with Cup Cushions, singles front, duals rear

Takes the Danger Out of Speedy Runs

The deep cups of the Firestone Cup Cushion Tire grip the slipperiest pavements with never-failing security and make this remarkable tire the safest known for fire apparatus.

Such dependability is actually the responsibility of every Department Head, both to the property owners in the community he protects and to his men.

Firestone Cup Cushion Tires have demonstrated everywhere that they are economical as well as safe. A special rubber compound is used that combines unusual resiliency with great wear-resistance.

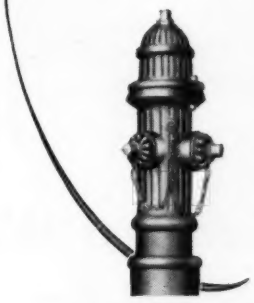
Follow the lead of the many Departments now using this tire, and of the many manufacturers of fire apparatus who have adopted it as standard equipment. It will help you hold down costs, increase the efficiency of your equipment and lower the possibility of casualties.

MOST MILES PER DOLLAR

Firestone

Cup Cushion Tires

Michigan Hydrants



The dependability which is so characteristic of all Michigan products is the reason back of the decided preference for Michigan Hydrants in an impressive list of cities.

Michigan Valve & Foundry Company

Established 1852

General Sales Office—First National Bank Bldg., Detroit, Michigan

Do You Have Obstructions In Your Service Pipes That Can Be Removed by 500 Pounds Water Pressure?

NEWARK BRASS WORKS

18–22 Lawrence Street

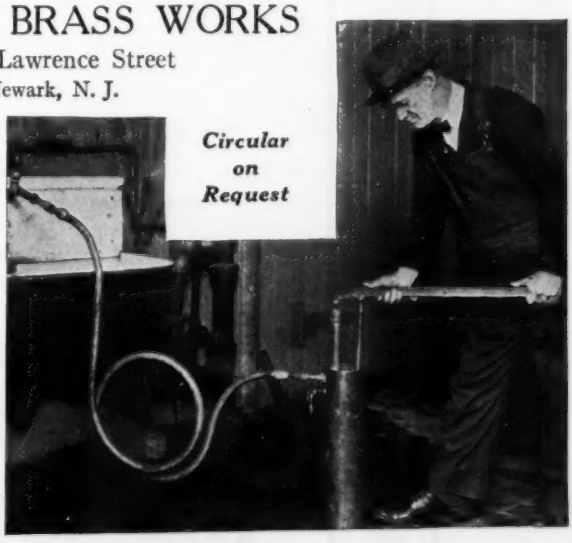
Newark, N. J.

THE LAWLESS FORCE PUMP

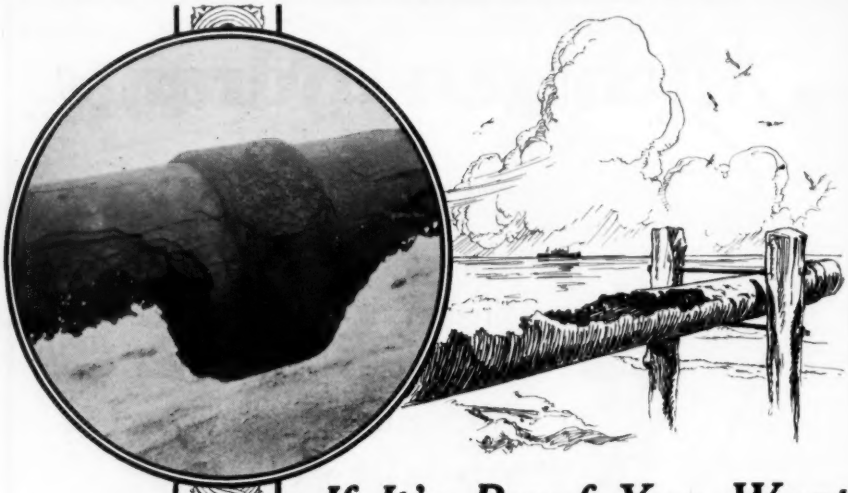
has been adopted by more than eighty water works since last May to remove such trouble.

Weight 19 lbs., Height 29 inches. Price $25.00 F. O. B. Newark, N. J. Easy to operate.

Sent on ten days' trial to any water works in U. S. A.



Circular on Request



If It's Proof You Want

These Wrought Iron Couplings Will Testify

TEN YEARS' exposure to the corrosive action of salt air and the sea-water reduced this steel pipe line to a useless shell of rust, held together only by the permanent grip of genuine Wrought Iron Couplings.

In spite of the severe action of salt water the condition of these couplings gives ample evidence of what would have resulted had the entire line been of the same enduring metal.

When you prudently specify Reading Genuine Wrought Iron Pipe the above illustration is a photographic proof of the service you can expect—and get.

READING IRON COMPANY
READING, PA.

World's Largest Manufacturers of Genuine Wrought Iron Pipe

Boston	Pittsburgh	Baltimore
Philadelphia	Chicago	Cincinnati
Seattle	New York	Los Angeles
St. Louis	Tulsa	Houston

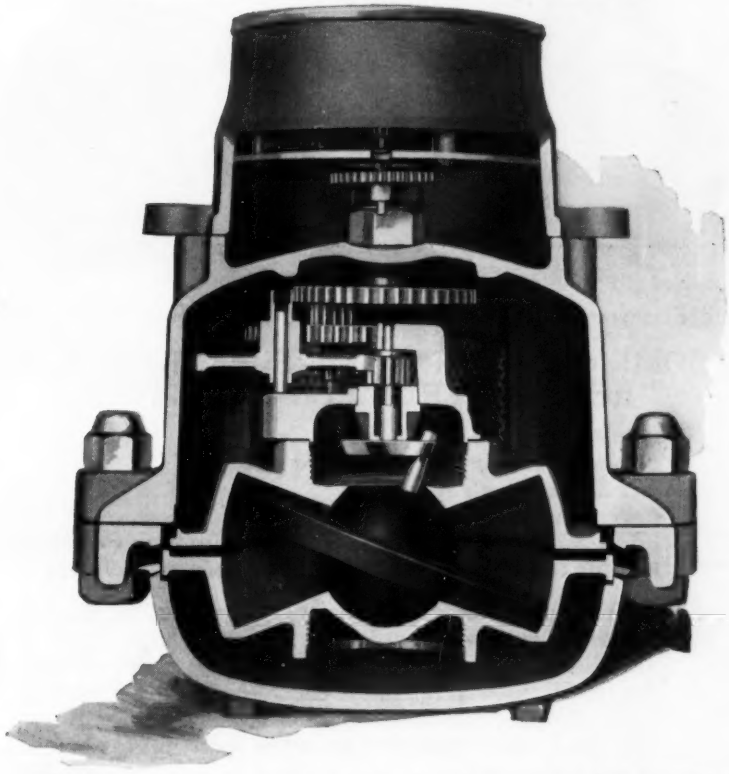
EST. READING 1848

READING PIPE
GENUINE WROUGHT IRON

AMERICAN AND NIAGARA

WATER METERS

WITH BREAKABLE FROST BOTTOMS (Patd.)



The sectional view shows a ⅝ inch meter cut at right angles to the line of pipe, the bottom casing burst by a "freeze up" and the parts of the intermediate gearing and disc chamber separated by the ice.

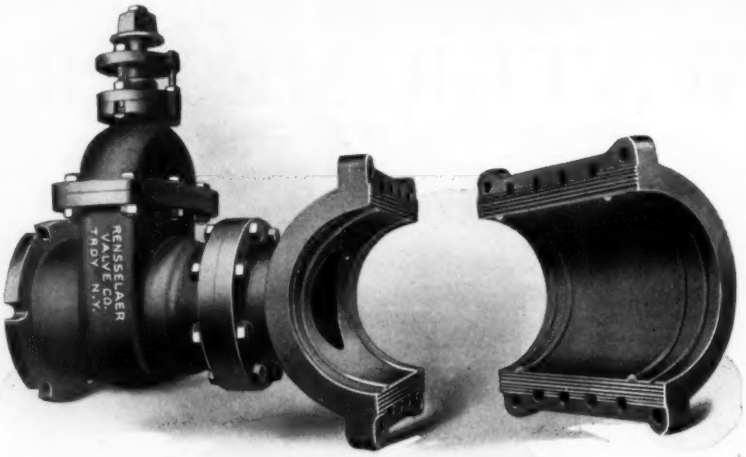
The breakable frost bottom is made of galv. cast iron but the main casing may be made of bronze or of galv. iron as may be required by service conditions. The intermediate runs on hard rubber bearings. All submerged working bearings are protected against sand and sediment.

Each meter is tested and guaranteed according to the Standard Specifications for Water Meters adopted by the American Water Works Association.

Write for catalog and prices

BUFFALO METER CO.

2914 Main St. **BUFFALO, N. Y.**



SOME of the POINTS OF SUPERIORITY of RENSSELAER TAPPING SLEEVES

Require ***less lead*** *for Calking*
Easier to center *on pipe* ***before pouring***
Give ***Extra Pipe Protection***
Bolts require ***No Iron Washers***
Each Size *carefully* ***designed for its Working Pressure***
Can be used with all Standard Tapping Machines

Rensselaer Tapping Sleeves are the only Sleeves on the market which are built with two Raised Rings which are a part of the Sleeve Casting itself. These Rings are used as Stops for the Hemp or Jute against which the Lead is poured to make the joint. In other types of Sleeves, without Rings, the Lead, when poured, fills entire space up to point at which cut is made.

The Raised Rings also permit easier centering of Sleeves on Pipe, also permit revolving Sleeve on pipe making it easier to tighten nuts on bolts which connect the two halves of the Sleeve.

The Bolting Flanges on all Sizes of Rensselaer Sleeves are made the full length of the Sleeve, permitting a greater number of bolts to be used back of point calked, giving greater protection to pipe at point where piece is cut out. This is especially important as in some cuts a hole nearly one-half the size of pipe is cut away.

BOOK No. 11 GIVES FURTHER PARTICULARS

RENSSELAER VALVE COMPANY

TROY, N. Y.

BRANCH OFFICES

NEW YORK, Hudson Terminal Bldg. **LOUISVILLE, Starks Bldg.**
CHICAGO, Monadnock Block **SEATTLE, Arctic Bldg.**
PITTSBURGH, Oliver Bldg. **NEW ENGLAND, C. L. Brown, Northboro, Mass.**

Warren Foundry and Pipe Company

(Formerly Warren Foundry and Machine Co.)

Manufacturers of

Cast Iron Pipe

Bell and Spigot Flanged

Special Castings and Fittings, Sizes 3″ to 60″

Our Motto for 67 years "Quality First"

Sales Offices

11 Broadway, New York 201 Devonshire St., Boston, Mass.

Water Gas Sewers Drains Railroad Culverts
Also Flexible Joint Pipe

Works: Phillipsburg, N. J.

BADGES

OFFICIAL BADGE

THE AMERICAN WATER WORKS ASSOCIATION

The above cut is a facsimile, enlarged, of the official badge or emblem of the Association. It is of gold and blue enamel made with a pin, but can be made into a button or watch charm The price in solid gold is $5.00 and they can be procured from the secretary.
For badges address

W. M. NIESLEY, Secretary,
170 Broadway, New York, N. Y.

These badges are not to be confused with the usual convention badge, but are for everyday use.

MAKE YOUR CAST IRON JOINTS

WITH

LEAD-HYDRO-TITE

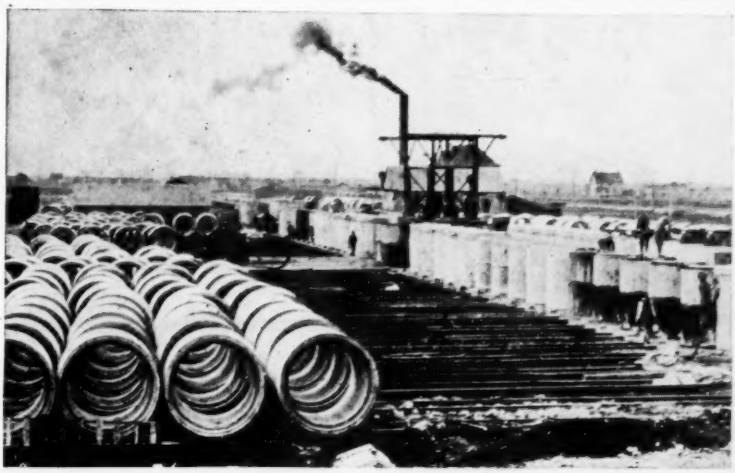
Trademark

AND CUT YOUR EXPENSES

50% FIRST COST
50% SMALLER BELL HOLES
75% HANDLING
100% CALKING

We will ship to prospective users, purchasing a trial lot of one to five bags, on the following terms. If after trial the purchaser is not satisfied, we will, on return of unused material, refund the price paid.

LEAD-HYDRO-TITE COMPANY
192 Boylston Street Boston, Mass.



Three Kinds of "Best"

WE make three types of pressure joints: The Lead and Iron Joint, the Lead and Steel Joint and The Copper Joint. All of these are, of course, Expansion Joints.

The requisites of a Reinforced Concrete Pipe Line, intended to carry water under pressure without undue leakage are: (1) Great density in the comparatively thin walls of the pipe, and (2) Joints between the pipe which are tight, which will remain tight under the varying conditions in a pipe line and which, in other words, are those manufactured by the Lock Joint Pipe Company.

"Every Joint an Expansion Joint"

LOCK JOINT
Reinforced
Concrete Pipe

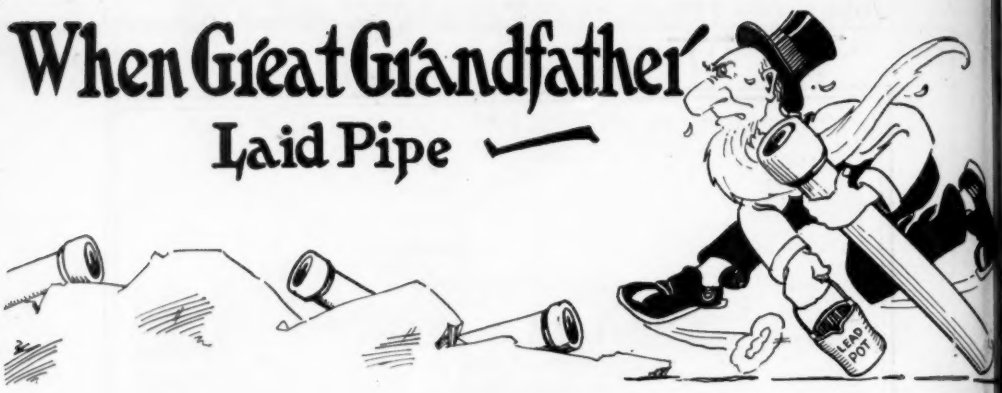
Pressure
Sewer
Culvert

Subaquecus
and
Centrifugal

LOCK JOINT PIPE CO.

14 Rutledge Ave.,
Ampere, N.J.

When Great Grandfather Laid Pipe



You could excuse—and forgive—his lead-pot, his bell holes, his hard slow calking all around the joints. There was no better way.

But the world progresses and *you* progress with it only if you change with it.

If you are spending some one's good money for the costly privilege of pouring your own pipe joints it is time to learn about McWane Precalked Joint Cast Iron Pipe. Our booklet AW describes it fully. Write for it *today*.

We make the smallest cast iron pipe manufactured in America—1¼, 2, and 3-inches—with bell and spigot factory-made lead and jute joints. Standard screwed cast iron fittings used with it. Rustproof and economical. Investigate.

UNUSUAL McWANE PIPE FACT No. 3
It can be laid three times as fast as ordinary pipe for half the labor.

McWane Pipe Costs Less!

McWANE CAST IRON PIPE COMPANY

General Offices Birmingham | **819 Bankers Trust Bldg. Philadelphia** | **1007 Central Building Los Angeles** | **1301 Magnolia Building Dallas**

MANUFACTURERS OF

McWANE PRECALKED JOINT PIPE CAST IRON

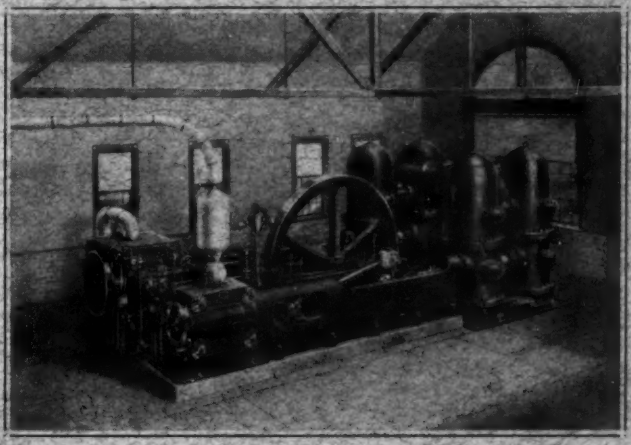
Sizes 1 1/4 through 6 inches. **Bell and Spigot type.**

MURRAY IRON WORKS CO.

(INCORPORATED 1870)

BURLINGTON, IOWA, U. S. A.

Builders of High Duty Pumping Engines



Murray High Duty Crank and Fly Wheel Pumping Engine, Opposed Type

Engineers, Iron Founders, Boiler Makers

Corliss and Una-Flow Engines

Water-Tube, Fire-Tube and Internal Furnace Boilers

Builders of Complete Power Plants

PLEASE SEND US YOUR SPECIFICATIONS AND CALLS FOR BIDS

TWELVE REASONS WHY

YOU SHOULD USE

TRADE "LEADITE" MARK

REGISTERED U. S. PATENT OFFICE

FOR JOINTING C. I. WATER MAINS

1—Durability. Leadite joints improve with age. Leadite was tested out for 10 years before it was placed on the market, and has now been commercialized for more than 15 years, giving it a life of over 25 years.

2—No Caulking. Leadite joints require no caulking because the Leadite adheres to the pipe, making a water-tight bond.

3—Comparative Quantities. One pound of Leadite is equivalent to four pounds of lead because Leadite is so much lighter than lead.

4—Labor Saving. Saves caulking charges and digging of large bell-holes and reduces the cost of trench pumping to the minimum, facilitating rapid completion of the work.

5—Cost. Its use saves at least 50% to 75% over lead, owing to the saving effected in material and labor.

6—Tools. As no caulking is required, fewer tools are needed.

7—Transportation. Considerable freight charges are saved because Leadite is lighter than lead, and therefore you move only one-fourth the weight of jointing material.

8—Electrolysis. Leadite resists electrolysis. However, electrical thawing apparatus may be used for thawing out frozen mains or services.

9—Fuel. Saves fuel because you melt only one pound of material instead of four and not as much heat is required to melt Leadite as is needed to melt lead. Leadite will not explode or splutter when poured into wet or damp joints.

10—Delivery. We can make prompt shipments.

11—Damage Suits. Claims for damages caused by joints blowing out are prevented because Leadite joints will not blow out under any pressure.

12—Users. Progressive water works all over the country use Leadite and thousands of miles of pipe jointed with Leadite are in service.

Leadite is the pioneer self-caulking substitute for pig lead.

Be sure it is Leadite, and accept no imitations.

THE LEADITE COMPANY, Inc.

LAND TITLE BLDG. PHILADELPHIA